NIST Global Cities Team Challenge (GCTC)
Utility SuperCluster Working Group

Best Practices Framework
For
Sustainable Energy, Water and Waste Solutions

NIST GCTC Expo
Washington, DC
August 28, 2017

Chair – Ed Davalos, Motorola Solutions
Water Co-Chair – Ken Thompson, CH2M
Energy Co-Chair – Derick Lee, PilotCity and Deborah Acosta, City of San Leandro, CA
Waste Co-Chair – Scott Pomeroy, Scalable Strategies

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Best Practices Framework for Sustainable Energy, Water and Waste Solutions

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INTRODUCTION: THE NIST GLOBAL CITY TEAMS CHALLENGE

The Global City Teams Challenge (GCTC) program is a collaborative platform for the development of smart cities and communities, led by National Institute of Standards and Technology (NIST), a bureau of U.S. Department of Commerce, in partnership with other U.S. federal agencies including National Science Foundation, International Trade Administration, and National Telecommunications and Information Administration. It enables local governments, nonprofit organizations, academic institutions, technologists, and corporations from all over the world to form project teams, or "action clusters," and "SuperClusters," to work on groundbreaking Internet of Things (IoT) and Cyber-Physical Systems (CPS) applications within the city and community environment.

The long-term goals are to establish and demonstrate replicable, scalable, and sustainable models for incubation and deployment of interoperable, standard-based solutions using advanced technologies such as Internet of Things (IoT) and Cyber-Physical Systems (CPS) and demonstrate their measurable benefits in cities and communities.

The Global City Teams Challenge grew from the White House technology initiative SmartAmerica Challenge. Its goal is to drive acceleration of technology through actively managed solution deployments addressing a wide array of problems facing cities in the United Stated and around the world.

Today, through NIST, the Global City Teams Challenge manages demonstration projects or action clusters through five SuperClusters. An action cluster is an actively managed deployed project involving a city or government entity and technology partners. A SuperCluster is a multi-city-stakeholder collaboration organized around common project objectives and shared solutions. The five SuperClusters include Transportation, City Platform/Dashboard, Public Safety, Utilities (Energy, Water and Waste Management) and Public WiFi.

The GCTC program has been successful in the recruitment and incubation of over 160 action clusters representing over 150 cities and 400 companies and organizations around the world.

The current SuperCluster focus is to manage their perspective action clusters with a final goal to create and publish a framework of best practices that can be used by cities around the world as a blueprint to build their own smart city strategies.

Click here for more information on SuperCluster groups.

THE UTILITY SUPERCLUSTER: SUSTAINABLE SOLUTIONS FOR ENERGY, WATER AND WASTE

The Utility SuperCluster theme on sustainability originated from an earlier technology demonstration at GCTC in 2015 called Smart Cities Optimized Action Cluster. The action cluster worked with the Las Vegas Valley Water District on Water Infrastructure Management and Leak Detection and was deployed successfully in three metropolitan cities in the United States.

With the focus on sustainability, the team wanted to raise awareness of the issue around water infrastructure management. Especially the fact that approximately 20-30% of a utility's water is lost in the network of pipes comprising their transmission and distribution system. This results in a staggeringly high global annual water loss of $14 billion. In the United States, this translates to 700 water main breaks per day or 250,000 annually for a typical water pipe leaking about 400,000 gallons of water per year. This also means nearly 9,000 kWh of energy are wasted annually.

This is a significant problem since for most utilities, buried water pipelines represent the largest value asset within their system and typically carry replacement costs in excess of $1,000,000 per mile. While looking for hard to find distribution and transmission leaks in water systems isn't new, the means now being used is: Internet of Things (IoT) technologies.

For example, with the evolution of cellular LTE, sensors and analytics, Mueller Water Products had commercially developed the EchoShore-TX permanent leak detection solution to collect, transmit and manage data. The monitoring platform combines acoustic leak detection technology with LTE cellular wireless connectivity and visual end-user dashboards to create a cost-effective monitoring solution.

As a result, Las Vegas initially deployed 13 permanent acoustic sensors monitoring 4 miles of the aging pipeline installed under Las Vegas Boulevard, from Sunset to Flamingo Roads, which resulted in the capability to monitor the transmission pipe continually for problems and leaks.

This project concluded that aging water infrastructure challenges will continue to escalate as buried pipelines throughout the nation near the end of their useful life, resulting in water loss, inefficient use of energy and property damage. Simply replacing or allowing these assets to run to failure is cost-prohibitive and not a sustainable infrastructure management approach. New pipeline monitoring technology combined with wireless communications and data visualization as demonstrated in the NIST Global City Teams Challenge are enabling utilities to cost-effectively gather more data to make more informed decisions. This directly leads to extended asset life, reduced operating risks and better management of water as a resource.

After the conclusion of the project, GCTC decided to bring together all other utility centric projects into one Utilities SuperCluster.

With the clustering of utility centric projects in 2015, the Utility SuperCluster was established at the annual GCTC fall meeting with contributions from 38 attendees comprising of individuals from government agencies, cities, universities, an international embassy, non-profit organizations and global technology and consulting providers. Since 2015, the Utility SuperCluster group has expanded to over 125 members in 18 action cluster projects.

The Utility SuperCluster

The purpose of the Utility SuperCluster is to address leading Energy, Water and Waste sustainability issues in cities by demonstrating real world examples and best practices. To do so, it brings together US

and global communities along with academia and technology partners. The SuperCluster is segmented into three groups with each group managed by its own working group co-chair. The Energy, Water and Waste working groups are responsible for managing active projects and developing high-level blueprints of replicable, scalable and sustainable solutions based on successful real-world examples and best practices. The goal is for this blueprint to be utilized by cities around the world as a way to jumpstart their efforts to create their own IoT-based technology roadmap.

High Level Purpose

In collaboration with the utility work session attendees, the group agreed to develop a high-level purpose that would serve as an overarching guide for adoption and acceleration of IoT technologies. Specifically, the group's aim is to address leading sustainability issues that impact cities by including academia and technology partners in solutions for the consumption side (reduced) and production side (increased), with focus on sustainability of energy, water, and waste.

Goals and Objectives

The main goals and objectives include saving energy and water to benefit cities and regions through innovative technologies by:

- Identifying new collaborative commons for energy, water and waste "clean tech" technologies
- Share finance and business models that work for both production and consumption
- Focus on solutions that account for water, increase conservation and increase energy production
- Highlight improvements and innovations for new technologies that save energy, water and money while growing the economy and protecting the environment
- Empowering citizens to be prosumers and consumers

Strategies and Approaches

With the creation of the SuperCluster, the group members were segmented into three vertical focused groups with each as a sub group for Energy, Water and Waste lead by a co-chair. The Utility SuperCluster is managed by Ed Davalos of Motorola Solutions as the working group chair with the following industry segment co chairs: Ken Thompson from CH2M managing Water; Deborah Acosta from the City of San Leandro and Derek Lee from PilotCity co-managing Energy; and Scott Pomeroy from Scalable Strategies managing Waste.

In order to align on a common approach and to develop a best practice framework, it was agreed to use a simple format capturing a problem statement, the cause of the problem, proposed solutions, benefits from the solution and a summary of a blueprint.

In developing the strategy and approaches, consideration was given to:

- Assessing the benefits and publishing findings (both tangible and intangible, what's tangible in future and other benefits like productivity)
- Developing social systems to track benefits

- Supporing communication and education
- Developingt and using IoT kits in K-12 education
- Determining how to leverage other industry groups to replicate/scale solutions
- Determining strategies for growth
- Parallel partnering opportunities, such as IEEE, American Water Works Association, American Society of Civil Engineers, EPRI, ACORE, ACEEE and other large industry associations
- Establishing regional groups and national hubs as the working group matures
- Creating a framework to address funding and finance issues

Addtional Organizational Considerations

With the three sub groups for Energy, Water and Waste created and organized, consideration was given to development of a Collaboration Plan, including adding city sustainability manager and networking groups to expand collaboration.

Consideration was also given to establishing Targets and Metrics, such as the templated Key Performance Indicator (KPIs) to measure program success based on life cycle cost reduction, GHG emission reduction, productivity improvements and customer satisfaction.

Founding Participants

The Utility SuperCluster working group was formed at NIST GCTC's fall summit in 2015 with contribution of the following cities.

List of Founding Participants

Cities and Government				
Gwinnett County,GA	Washington, DC	U of Vermont	Downtown DC BID	Burkina Faso, Niger
Charlotte, NC	Burlington, VT	Winooski, VT	Suraj Energy	Goyang City Korea
Spokane, WA	Chattanooga, TN	Metro Council of Gov't	Republic of Congo	U.S. Dept. of Commerce
Dallas, TX	San Diego, CA	Goyang, South Korea	City of Chula Vista	UT at Chattanooga
Loudoun Water	City of KC MO	Embassy of Italy	Georgia Tech	City of Bellevue
Montgomery County, MD	Ghana, Benin, Togo	NIST/Santa Clara University	Downtown DC BID/Washing DC	City of San Leandro, CA

Consultants and Technology Providers			
CH2M	Cleanech San Diego	Black & Veatch	Qualcomm
Scalable Solutions	Ingenu	Fiware/InterInnov	Strateq
AT&T	LG Uplus	IoT Dev Labs	SAP
IBM	Phillips	PNNL	McKinsey & Co.
Smart City Capital, LLC	ATIS	Zip Power	Itron

Utility SuperCluster founding working group October 25, 2016

Technology and Cross Cutting Elements in IoT

Technology and cross cutting elements in IoT were considered which the group recognized to include IoT Communications, Hardware, Data Analytics and cross industrial and application funding. After evaluating where to best focus the group's effort, Security and Funding were pursued as two horizontal areas of blueprint framework efforts.

ENERGY WORKING GROUP FRAMEWORK BEST PRACTICES

Starter Guide

We are excited to share with you the trajectory, vision and intent of our Energy SuperCluster. First and foremost, we would like to make a few statements:

- We want you to submit a Success Story Submission (S3) via the link: www.bit.ly/escs3, to become a member of our SuperCluster.
- Submitting a S3 generates and delivers an Energy SuperCluster Report (ESR) to you via email that gives you insights and recommendations for partners and clients.
- You can view ESRs of existing members in our public folder: www.bit.ly/escpublic.

The big idea is, we believe our SuperCluster Leadership Team will not decide the fate of energy innovation in our world, we believe that we all will. To this end we aim to achieve together:

- A collection of Success Story Submissions (S3) of energy innovation projects from across the world to identify patterns, themes, lessons and practices that get shared publicly as a Living Blueprint, in addition to exporting Energy SuperCluster Reports (ESR) back to members who submit S3s.

- Success Story Submissions (S3) totaling (100) by December 31st, 2017, (250) by end of 2018, and (500) by end of 2019. To this date (August 24th, 2017), we have a total of (45) S3s collected.

- An Average Scalability Factor of 25x by 2019 compared to the current Average Scalability Factor of 2x based on the S3s collected.

- **A** model where projects are 75% revenue funded by 2019. According to our current S3s, 36% of energy innovation projects are grant funded, 27% privately funded, 15% city funded, and only 8% revenue funded.

- To grow the network of the deployment cities in our network from (28) cities to (100) cities by 2019 for energy innovation projects.

- To work with universities to have their students operate our SuperCluster.

- To work with partnering organizations and companies to create an automated platform for Success Story Submissions (S3), Matchmaking (MM) and Blueprinting.

Ingredients

Success Story Submission (S3)

An energy innovation project submission to the Energy SuperCluster to receive an Energy SuperCluster Report (ESR), join as an official member of our SuperCluster, and receive Matchmaking (MM) services to individuals and organizations in the network. Submit an S3 here: www.bit.ly/escs3

Energy SuperCluster Report (ESR)

A PDF document that submitters of Success Story Submissions (S3) receive that includes an exported format of their Organization Profile, Success Story, Insights Dashboard (ID), Partner Recommendations, Clients Referrals and Actions. View ESRs here: www.bit.ly/escpublic

Warm Introductions

Primary benefit of being a member of the SuperCluster by submitting a Success Story Submission (S3). The ability to request a warm introduction via email from our team to anyone in our network to spur discussion, opportunities and projects. Request a Warm Introduction here: www.bit.ly/escintro

Matchmaking (MM)

A system that encodes Success Story Submissions (S3) that match individuals and organizations together in the form of Partner Recommendations and Client Referrals.

Partner Recommendations

List of recommended partners within our network that is included in the Energy SuperCluster Report (ESR) that our Matchmaking (MM) system generated for you.

Client Referrals

List of potential clients within our network that is included in the Energy SuperCluster Report (ESR) that our Matchmaking (MM) system generated for you.

Insights Dashboard (ID)

A living reference guide derived from the Living Blueprint of energy project categories (Energy Efficiency, Internet of Things, Distributed Energy, etc) that compare your project data with similar projects in network.

Living Blueprint

A living guide (and whitepaper) aggregating processed, formatted and referenceable Success Story Submissions (S3) to create and share a wealth of energy innovation best practices, lessons learned and insights to the public.

Committees

Members of the SuperCluster that are selected to review formatted and aggregated Success Story Submissions (S3) to apply expertise on qualitative and quantitative data to generate an updated Living Blueprint referencing system. Apply to the Committees here: www.bit.ly/escteam

Cities & Policy Committee
Members that provide expertise on energy innovation as it applies to governmental functions, regulations, policy and other civic challenges.

Technology & Data Committee
Members that provide expertise on energy innovation as it applies to technology solutions, technical applications, data science and other technical challenges.

Finance & Business Model Committee
Members that provide expertise on energy innovation as it applies to financing projects, business model development, scalability and other monetary challenges.

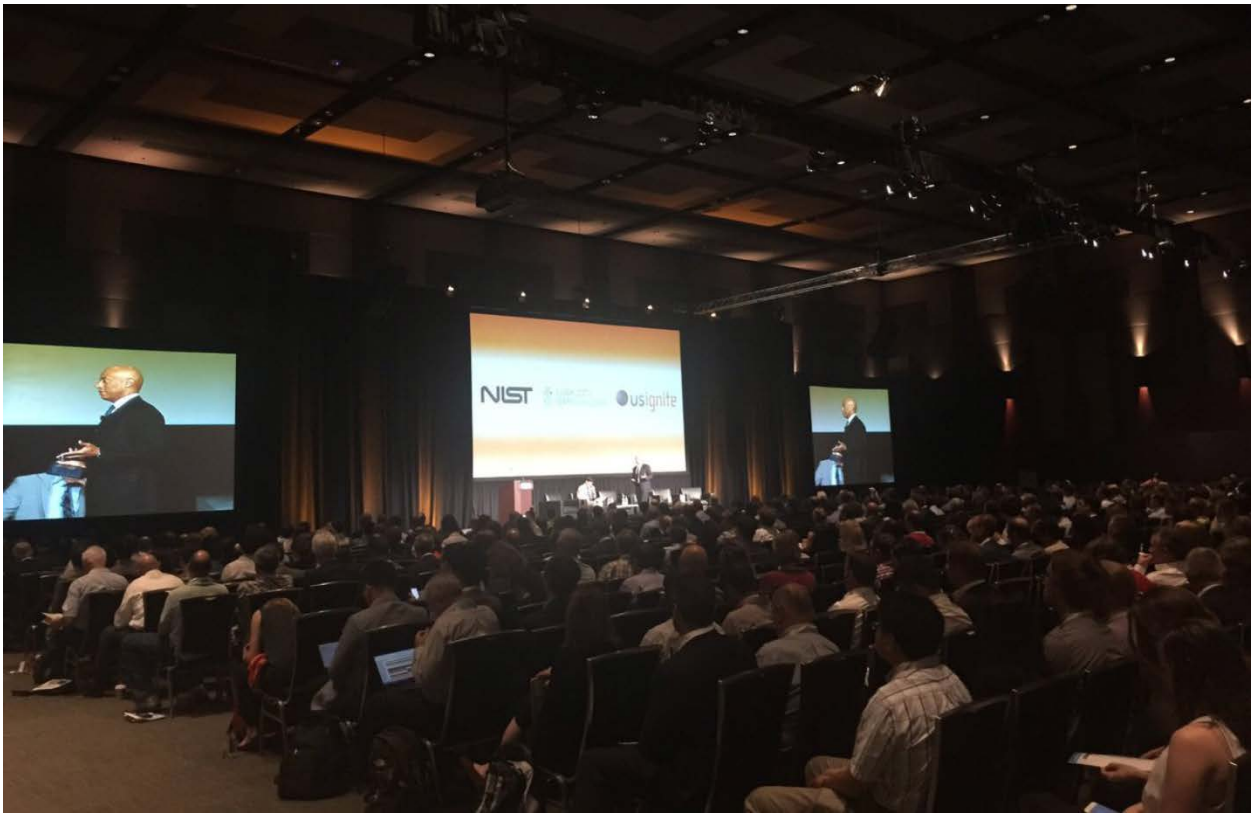
Blueprint Factory
The complete blueprinting production system that includes all core functions such as the processing of Success Story Submissions (S3), Committees, Insights Dashboard (ID), Matchmaking (MM) System, and production of Energy SuperCluster Reports (ESR).

Mavens Team
Team members that recruit members to the SuperCluster via Success Story Submission (S3). Join the team here: www.bit.ly/escteam

Blue Team
Team members that process Success Story Submissions (S3), review data via Committees, produce Energy SuperCluster Report (ESR), match individuals and organizations through the Matchmaking (MM) system, and operate the entire SuperCluster. Join the team here: www.bit.ly/escteam

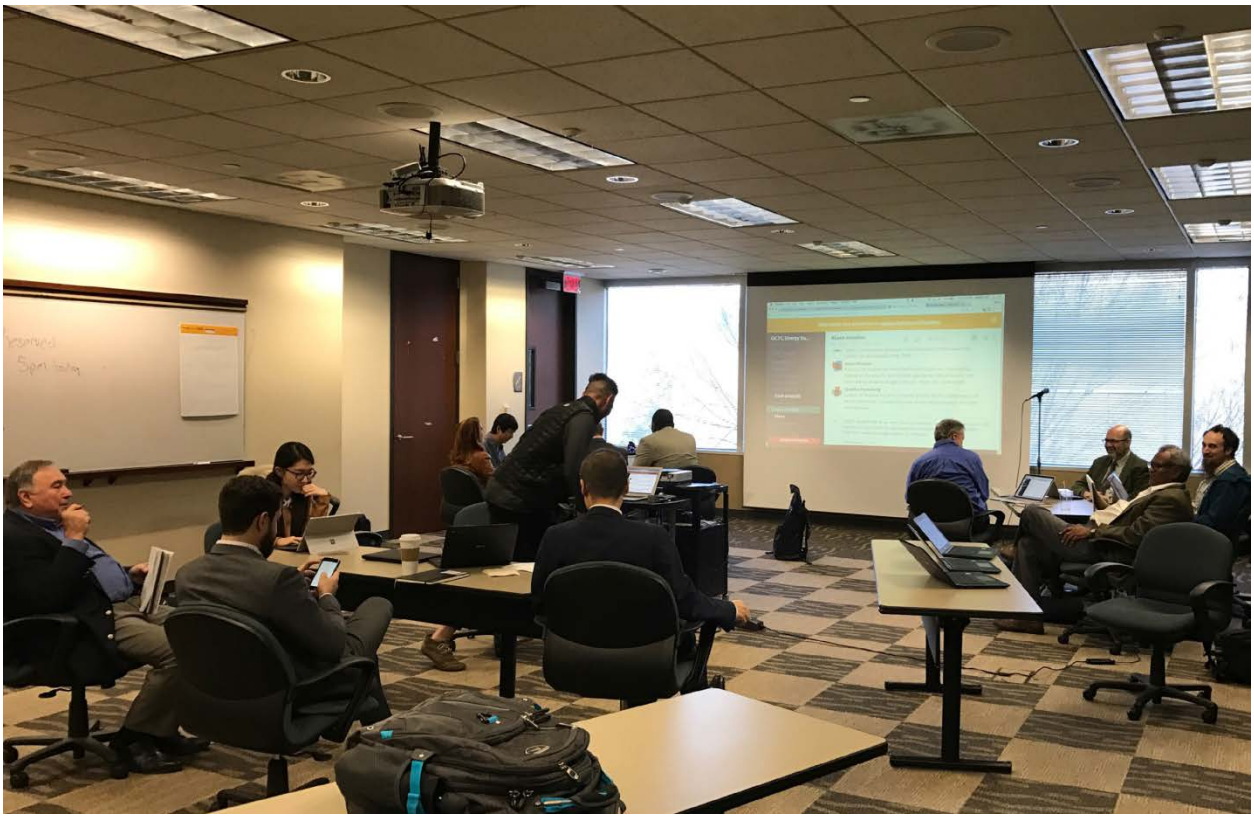
Connectors Team
Team members that deliver Energy SuperCluster Reports (ESR) to submitters of Success Story Submissions (S3) and make warm introductions to member requests. Serves also as a community manager. Join the team here: www.bit.ly/escteam

Energy Innovation Incubator
The definition of what our SuperCluster is with the purpose of advancing our network of energy innovators to spur market transformation of energy consumers to become energy prosumers towards a sustainable and resilient future in our world.



2016 NIST Global Cities Team Challenge (GCTC) Expo in Austin, TX

Utility SuperCluster's First Working Session in Atlanta, GA, March 2017

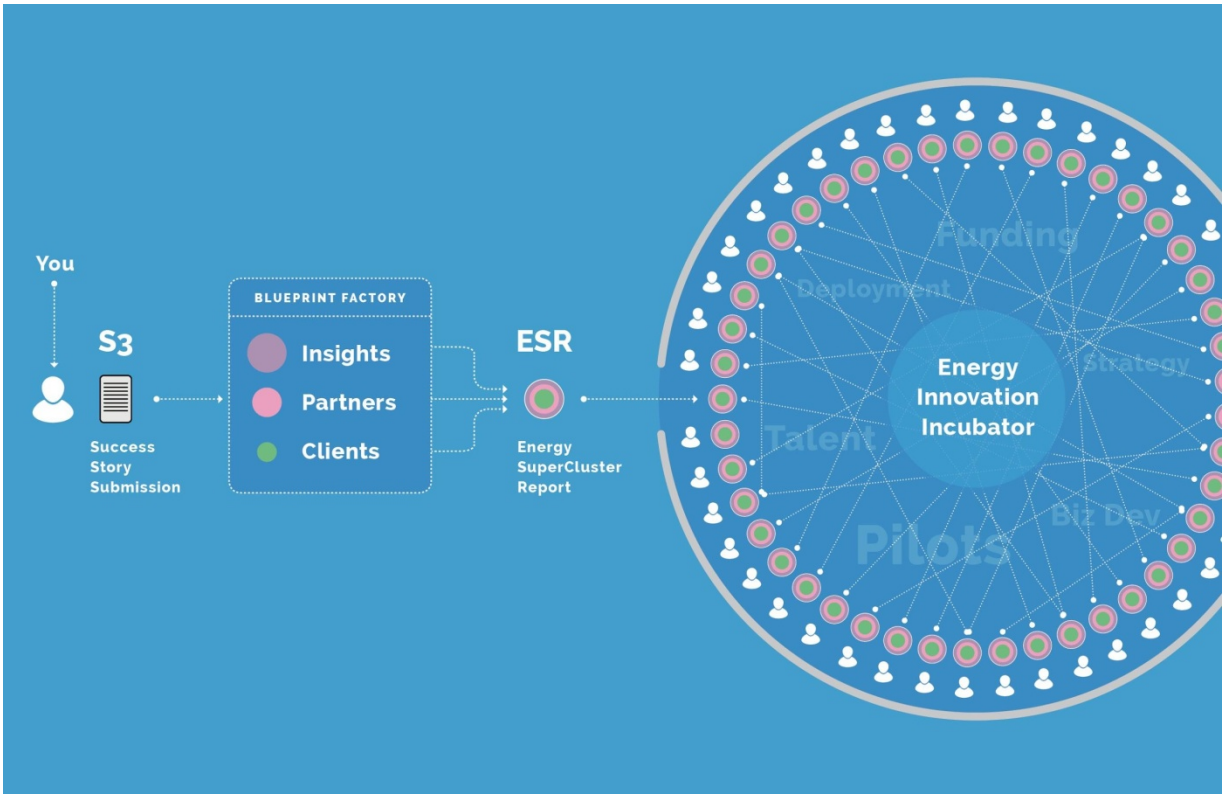


Energy SuperCluster Working Group and Breakout Session in Atlanta, GA, March 2017

About the Energy SuperCluster

The Energy SuperCluster is embedded in the Utility SuperCluster of the NIST Global Cities Team Challenge (GCTC) Network. We are a cross-sector consortium of city governments, universities, industry leaders and community-based organizations on a mission to advance energy innovation in cities across the globe. Our SuperCluster believes our leadership team alone will not decide the fate of energy innovation in the world; we believe that we together will. In order to achieve this, our primary function is to recruit and collect Success Story Submissions (S3) of energy innovation projects from around the world. We process these success stories through our Blueprint Factory to create a referenceable data-driven Living Blueprint. Through this Living Blueprint, we include a review system by Committees, Insights Dashboard (ID) that compares and contrasts S3 projects with related success stories, and a Matchmaking (MM) system that recommends partners and clients within our network. The deliverable we send back to the individual or organization that submitted a Success Story Submission (S3) is an Energy SuperCluster Report (ESR) which includes the Insights Dashboard (ID), Partner Recommendations and Client Referrals. Once the ESR has been delivered, members can request warm introductions to anyone within our network that have also submitted S3s as a matchmaking service to spur discussion, opportunities and projects. The aim is to create more projects in our network to further understand best practices, increasing the scalability factor of energy innovation in our cities.

Energy SuperCluster Overview Architecture Map



Leadership Team

As of August 24th, 2017, the current roster of organizations in our leadership team includes:

- AT&T
- City of Atlanta
- City of Portland
- City of San Leandro
- Clemson University
- Dekalb County
- Everimpact
- FIWARE
- Innovation Intelligence Institute
- InterInnov
- KC Digital Drive
- Lawrence Berkeley National Lab
- Maalka
- OSIsoft
- PilotCity

- Scalable Strategies
- The Green Link Group
- University of Georgia
- University of Tennessee
- US Department of Energy
- ZipPower

Our leadership team currently consists of (3) Sub-Teams and (3) Committees:

- Mavens Team
- Blue Team
- Connectors Team
- Cities & Policy Committee
- Technology & Data Committee
- Finance & Business Model Committee

** You can find the definitions of each team in the Ingredients section above.*

Mavens Team

- Mike Mihuc, Market Principal, Academic R&D, OSIsoft
- Billy Malone, Environmental Energy Manager, Dekalb County
- Lusenii Watson, SolSmart Consultant, City of Atlanta

Blue Team

- Derick Lee, Chief Architect, PilotCity
- Caroline Hays, Fellow, City of San Leandro
- Tianzhen Hong, Principal Investigator, Lawrence Berkeley National Lab
- Paul Wertz, Client Solutions Executive, AT&T
- Taylor Hill, Student, University of Georgia
- Romney Cola, Fellow, PilotCity
- Guneet Bedi, PhD Student, Clemson University

Connectors Team

- Géraldine Quetin, Senior Consultant, InterInnov / FIWARE
- Scott Pomeroy, President & CEO, Scalable Strategies

Cities & Policy Committee

- Chair: Billy Malone, Environmental Energy Manager, Dekalb County
- Deborah Acosta, Chief Innovation Officer, City of San Leandro
- Matt Cox, Co-Founder, The Green Link Group

- Aaron Deacon, Managing Director, KC Digital Drive
- Katherine Hambrick, Project Coordinator, KC Digital Drive

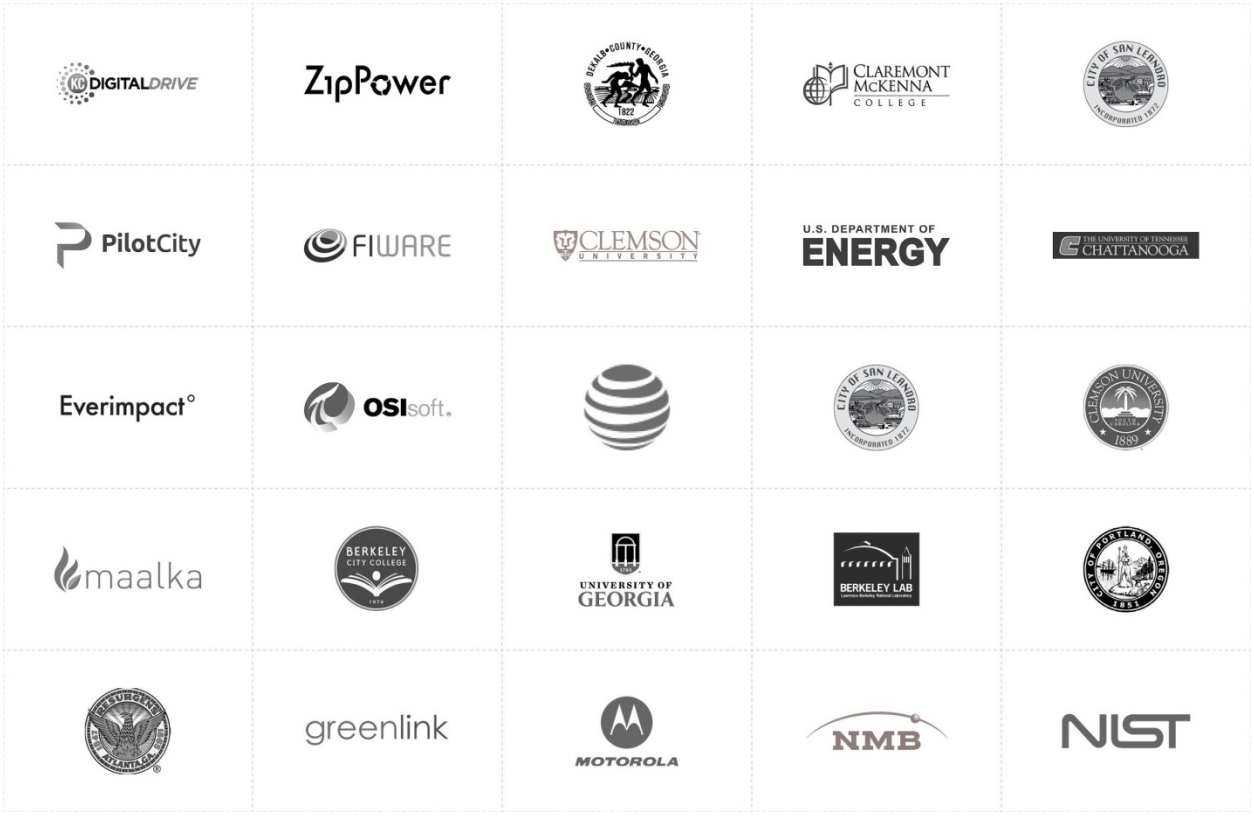
Technology & Data Committee

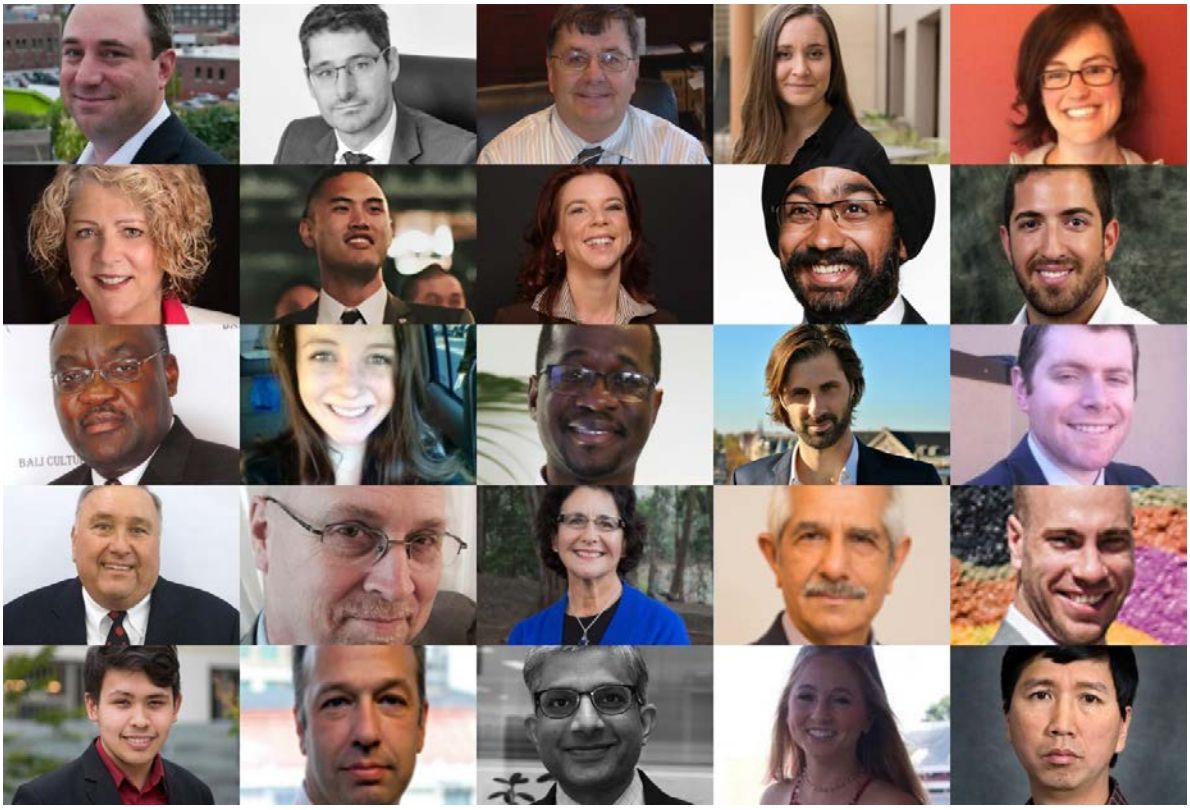
- Chair: Rajendra Singh, Professor, Clemson University
- Harry Bergmann, Data Tools Fellow, US Department of Energy
- Mike Mihuc, Market Principal, Academic R&D, OSIsoft
- Tianzhen Hong, Principal Investigator, Lawrence Berkeley National Lab

Technology & Data Committee

- Chair: Mathieu Carlier, CEO, Everimpact
- Rimas Gulbinas, CEO, Maalka
- John Teeter, Chief Innovation Officer, Maalka

Energy SuperCluster Leadership Team Organizations & Photos


DIGITALDRIVE
ZipPower
DEKALB COUNTY GEORGIA
CLAREMONT McKENNA COLLEGE
CITY OF SAN LEANDRO
PilotCity
FIWARE
CLEMSON UNIVERSITY
U.S. DEPARTMENT OF ENERGY
THE UNIVERSITY OF TENNESSEE CHATTANOOGA
Everimpact
OSIsoft.
CITY OF SAN LEANDRO
CLEMSON UNIVERSITY
1889
maalka
BERKELEY CITY COLLEGE
UNIVERSITY OF GEORGIA
BERKELEY LAB
CITY OF PORTLAND OREGON
greenlink
MOTOROLA
NMB
NIST

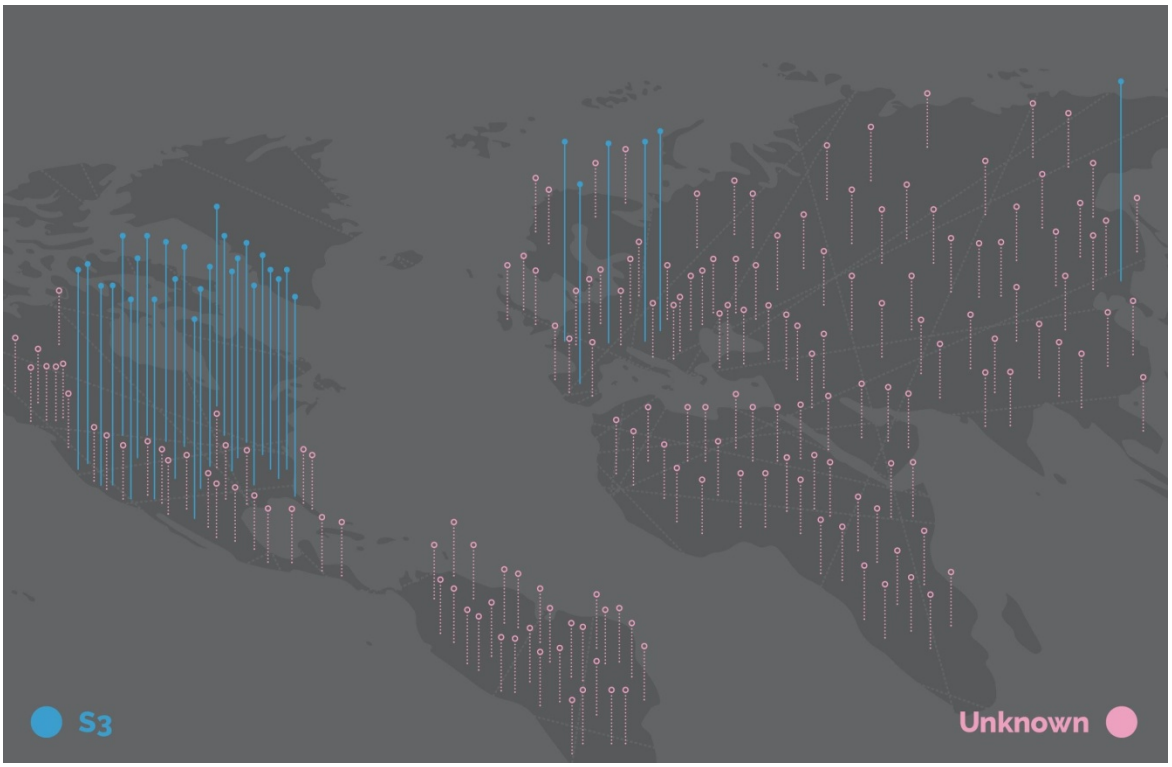


Success Story Submission (S3)

The Success Story Submission (S3) is currently a Google Form that takes an average of 30 minutes to complete. It consists of questions with various response choices from short answers, long answers, multiple choice and checkboxes. Category areas of questions include:

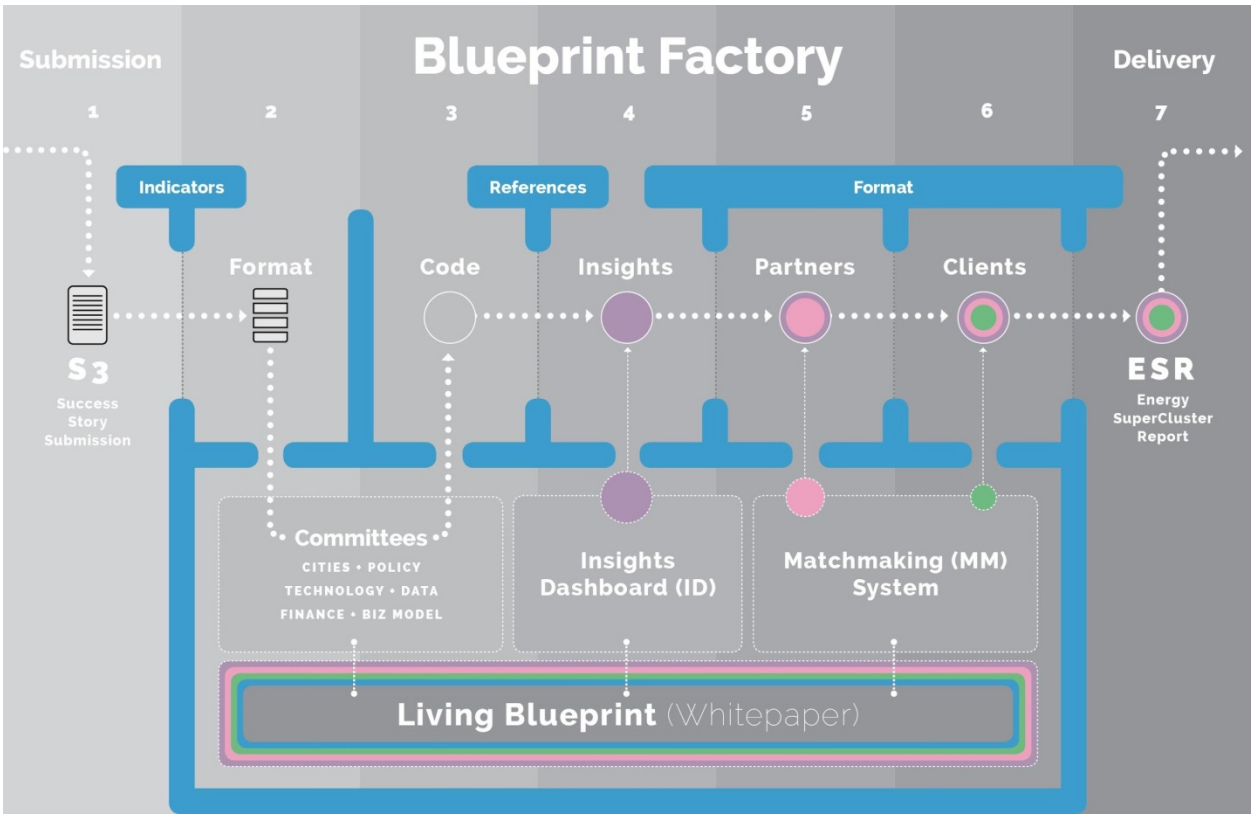
- General Information
- Ecosystem
- Timeline
- Business Model
- Technology
- Data
- Policy
- Finances
- Impact

These category areas allow us to process the data from each in sections, with in turn allows us to format it for the Blueprint Factory to process. You can view the Success Story Submission (S3) here: www.bit.ly/escs3



Blueprint Factory

The Blueprint Factory is the system and mechanisms that currently process the S3s into digestible formats for each individual layer of applicable value: Committee Review, Insights Dashboard (ID), and Matchmaking (MM). This Blueprint Factory has a multitude of functions that are currently analog and has extreme potential to be automated to update the Living Blueprint, automated Matchmaking (MM), and instant Energy SuperCluster Report (ESR) production and delivery.



As you can see from the above diagram, the Blueprint Factory has a multitude of systems that format, code, reference, update and produce content in a living system. As S3s are submitted, the Living Blueprint will evolve, and become richer over time. This maturity will create a more established Committee, greater accuracy for the Insights Dashboard (ID) and a more robust Matchmaking (MM) System. In return, this will develop a stronger Energy SuperCluster Report (ESR) to be delivered straight back to the submitter of the S3.

Energy SuperCluster Report (ESR)

The ESR is currently a template in Adobe InDesign that can be exported into a PDF format to be emailed to the individual or organization that submitted a S3. The ESR's standard content includes:

- Cover Page
- Table of Contents
- Organization Profile
- Success Story Profile
- Insights Dashboard (ID)
- Partner Recommendations
- Client Referrals
- Actions

You can see the Energy SuperCluster Report (ESR) Library here: www.bit.ly/escpublic.

Above, you will see an example of an Energy SuperCluster Report (ESR) delivered back to Deborah Acosta, Chief Innovation Officer of City of San Leandro for her *Smart City Lights* S3 submission. As you can see, she does not have any Client Referrals due to her being a city municipal government. In the future, we imagine a potential Vendor Recommendations sheet to recommend to purchasers such as municipal governments.

Blueprint Snapshot

Above, you will find an aggregate of data that has been averaged out to create a distilled and simplified number of what the current S3s have produced in terms of insights. We have found that these general numbers have been useful to understand where we are from a benchmarking perspective to better share with others where we are, how we need to move forward and what goals to establish as a community of energy innovators.

Living Blueprint

State of the Field

We collected Success Stories from (45) smart city energy projects to learn about the current state of the field. The following information states the aggregate of data we received and processed.

Organization Type

- Government - 3 Cities
- Education - 18 Universities
- Community - 3 Non-Profit Organizations
- Industry - 5 Software Companies
- Industry - 8 Integrated Technology Companies
- Industry - 8 Services Companies

Organization Offerings

- Software - 29 Organizations
- Services - 17 Organizations
- Research & Development - 28 Organizations
- Governance - 2 Organizations
- Hardware - 9 Organizations
- Consulting - 2 Organizations

Project Types

- Energy Efficiency - 34 Projects
- Energy Management - 27 Projects
- Energy Generation - 17 Projects
- Electric Vehicles - 11 Projects
- Internet of Things - 34 Projects
- Distributed Energy - 18 Projects
- Microgrids - 16 Projects
- Process Improvement - 1 Project

- District Scale Applications - 1 Project
- Air Quality Monitoring - 1 Project
- Service Improvement - 1 Project
- Cloud Data and Analytics - 1 Project
- House Air Quality - 1 Project
- Housing Environment - 1 Project
- Efficient Trash Collection - 1 Project
- Demand Response - 1 Project
- Mapping & Control - 1 Project

Project Scope & Location

- Building Level - 27 Projects
- Multi-Building Level - 18 Projects
- Block Level - 12 Projects
- District Level - 22 Projects
- Citywide Level - 21 Projects
- Region Level - 3 Projects
- National Level - 1 Project
- Statewide Level - 0 Project
- International Level - 2 Projects

Project Missions & Goals

Projects had a wide variety of goals and missions. Some of the more common categories are listed below. Educating students, generating data and providing information were the most common project goals.

- Reduce Costs
- Generate Date & Provide Information
- Demonstrate & Test Concepts
- Reduce Energy Usage & Demand
- Improve Quality of Life for Citizens
- Community Education (Especially Students & Government)
- Build & Improve Infrastructure
- Build New Software Systems
- Meet Emissions Reduction Goals
- Growing a Business

Problems

Three common types of problems emerged:

1. A need to transition to renewable energy, often to meet targets
2. High energy costs
3. A lack of available, high quality data to inform decisions and processes and a lack of systems to harness this data once available

Solutions

Three primary types of solutions to these problems were pursued by projects:

1. Upgrading infrastructure
2. Creating knowledge, often through monitoring and data collection
3. Creating systems and practices informed by data

Influencing regulation and facilitating collaboration among partners were also noted solutions.

Challenges

Projects faced a number of challenges related to business, engagement, policy and regulation, and technology. Many challenges reached across categories. For example, scaling was a challenge due to the level of financial and human resources needed to do so, as well as the technical challenge of generalizing a system built specifically for one city.

Technical Challenges

- Technology Integration with Existing Systems
- Data Security
- Ability to Obtain Necessary Data
- Scaling

Business Challenges

- Business Model Viability
- Financing
- Resource Availability
- Resources for Scaling
- Customer Recruitment & Retention
- Vendor Participation

Engagement Challenges

- Stakeholder Coordination
- Understanding User Behavior
- Technology Acceptance & Adoption

Policy and Regulation Challenges

- Municipal Processes
- Obtaining Data from Government
- Policy Environment

Lessons Learned

Five major categories of lessons learned emerged.

Technology Specific Lessons

Teams learned how to solve challenges they faced with their specific technology, whether it was maintaining the efficiency of geothermal systems or overheating air quality monitors.

Be Patient

Project teams learned that stakeholder engagement and working in the complex realm of government regulations can take longer than anticipated. One committee member stated:

> "Making changes in local government processes takes time. Building collaboration and being patience and persistence is necessary to being successful. Do not give up no matter the challenge."

Stakeholder Engagement is Key

Project teams learned that engagement of all parties is crucial for success, whether that is local government, the owners of buildings, or citizens affected by the project.

> "Building owner and tenant engagement is vital to program success"

> "Regional collaboration between the public, private and academic sectors is key."

Mismatched Abilities & Approach

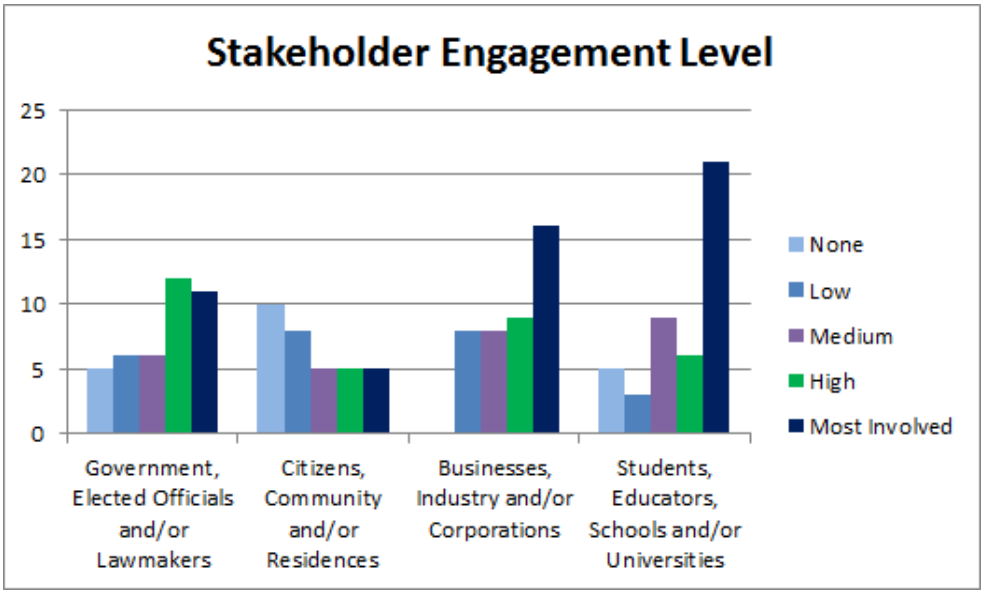
Project teams learned that the state of technology and possibilities often did not match the approaches being taken by government or other organizations. As an emerging field, projects will need to learn to manage the tension of modernizing practices along with technology.

Business Lessons

Project teams also learned how to create new businesses and business models.

> "It takes time to create a new business management model."
>
> "Understand your customer needs both during initial contact & during pilot, as well as production deployments. Never assume their needs."
>
> "Start with a product that focuses on the needs of the early adopters to initiate revenue."
>
> "Generate Key Performance Indicators (KPI) during pilot and production deployments. These are essential for ensuring further Venture Capital (VC) investment."

Engagement



Energy Education for Community

Citizens and government emerged as the two clear groups that project teams needed to educate for their project to succeed. There was a range, however, in which groups within government were

important to project success. Some listed elected officials at the local level as most important, while others focused on government technicians and operators or regulators and zoning officials. Businesses and universities also emerged less frequently as important groups to educate.

Metrics for Success

Projects utilized a broad range of metrics for their success, often using metrics across categories.

External Designations	● Government Certification ● SolSmart Designation (US Department of Energy)
Business	● # of Clients ● # of Project Sites ● # of Website Visits ● # of Services Provided ● # of Product Adoption in Projects
Environmental Benefits	● Pollution Reduction ● Energy Savings (Reduced utility bills, excess power sold to the grid, Co2 emission reductions, measured energy consumption)
Product Effectiveness	● Product Reliability ● Avoid Need for Infrastructure Investment ● Reduction in Maintenance Cost, Duration, and Visits for Clients ● User Feedback ● Electric Vehicle (EV) Adoption
Economic Impact	● Green Jobs Creation ● Economic Stimulus ● Economic Opportunity Creation

Results: Business and Finance

<u>Project Costs</u>

- Average Cost - $10,065,449
- Median Cost - $500,000
- Range - $11,000 - $150,000,000

Project Funding Sources

- Grants - 36%
- Private Investment - 27%
- City Funds - 15%
- Revenue - 8%
- Savings - 8%
- Shareholders - 1%
- Sponsorships - 1%
- Foundations - 2%
- University Funds - 1%

Project Length

- Average - 778 days
- Median - 372 days
- Range - 151 - 8735 days

Project Completion Stages

- Average - 59%
- Median - 60%
- Range - 0%-100%

Lessons Learned

It's a relatively new field and this is reflected in the low number of replications of projects and the large number of pilot projects. Business models, funding, and stakeholder partnerships tend to be the limiting step for new projects, rather than technological capabilities.

Looking Forward

- Shift metrics for success to focus on measurable impacts for residents and citizens. More specific, measurable impacts will help justify funding and align priorities and goals among stakeholders.
- As projects mature and move out of pilot stages, increasing funding will be required. Attracting private capital to governments will help these projects scale, but currently, risk and misaligned processes can hinder partnerships between government and private capital. Looking forward, stakeholder engagement that brings all relevant parties together and provides pathways for partnership that can support scaling projects will be essential to success.

Results: Cities and Policy

Levels of Government Engaged

- Municipal - 32
- County - 12
- State - 16
- Federal - 23
- International - 4

Policy Innovations

What policy innovation(s) are projects actively solving for?

Major Themes

- Gaining data access
- Updating permitting, building codes, benchmarking requirements, and other policies.

Other Notable Policy Innovations

- Inclusion of smart city work in city's general plan
- Creating financing, including incentives and rebates, to support projects.
- Updating utilities' policies and rate structures to accommodate new technology and systems
- Using performance contract design to help mitigate risk to cities
- Pursue disclosure ordinances through municipal governments to gain access to data

Policy Challenges

- Access to Data
- Permitting, Zoning, or Regulation Hurdles
- Policy Area Undeveloped

Lessons Learned

Data access is a major challenge for many projects. While policy can be a hurdle to accessing data, it can also aid in obtaining data if municipalities pass disclosure ordinances to encourage or require the sharing of data.

Looking Forward

- While utility rate structures were not listed as a common barrier in this round of projects, we anticipate it becoming a more common problem as projects advance and scale. Updating rate structures to allow for the successful integration of new energy sources and new energy

management practices will become increasingly essential to project success. Collaboration and best practice sharing across regions can aid this process.

- Permitting, zoning, and regulations were frequently cited barriers, but a more detailed classification of specific policy types is still unknown. Working to learn the specific policy challenges that projects face and collectively working to establish models and best practices to overcome them could help future projects face fewer hurdles.
- Financing is a common barrier for governments, especially when policies constrain their financing avenues. Learning more about policy barriers to financing and working to change them could aid future projects. For example, performance contract design is an attractive finance model to governments, but was previously against regulations in Georgia. Changing that policy has opened new possibilities for financing projects there.

Results: Data and Technology

Primary Data Types Collected

- Energy Consumption - 39
- Energy Generation - 23
- Internet of Things (IoT) - 35
- Distribution & Transmission - 13
- Environmental Quality - 22
- Financial - 19
- Policy - 15
- Time - 11

Other Types Mentioned

Process improvement and changes, geo-info, parking, building permits, energy disclosure ordinances, Building automation, water consumption, weather parameters, lighting & utilities.

Technology Types

- Hardware - 18
- Integrate - 37
- Software - 36

Technology Ownership

- Organization Owned - 30
- Owned by Others - 11
- Collaboration - 2
- Mixed Model - 2

Technology Success Ratings (Scale of 1-5)

- Average - 4.5 of 5
- Median - 5 of 5
- Range - 3 to 5

Reported Data Benefits (5 Main Categories)

1. Public access to information and education
2. Cost savings
3. Benchmarks and project evaluation (ROI's can be measured)
4. Improved compliance measurement by city
5. Enable more targeted responses and interventions

Lessons Learned

Data Access is one of the largest and most common barriers that projects face. There are a number of ways to address it, including policy advocacy as well as technical workarounds. One project simulated building level energy usage data and then compared its estimates to aggregate data that was available. Others contracted with external organizations that specialized in retrieving data.

Looking Forward

- Move towards standardizing data formats as projects do gain access to it. This can mitigate transaction costs transferring data from one format to another.
- Integrate considerations for resiliency, sustainability, and equity intro projects missions and goals. These can be integrated into metrics for success and als influence the type of data monitored and the deployment of technology.

Conclusion

The story is not finished yet. We consider this a beginning to the journey, fight, failures and successes of energy innovation in our cities. The primary conclusion we have identified from this process is that we are building a culture of momentum in an inventive period as our infrastructure is digitized. We are both doing work in market and spurring a cultural transformation. It is as much a social dynamic as it is a political, financial or technological puzzle to discover what it means to be a smart city, particularly with fundamental resources such as utilities.

The number one call-to-action before concluding this first version of the energy blueprint is: *contribute to it.* Spend 30 minutes of your time to fill out a Success Story Submission (S3) at: www.bit.ly/escs3.

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WATER WORKING GROUP FRAMEWORK BEST PRACTICES

Nearly every discipline – from sports and advertising to public health and science – relies on data-driven analysis for decision-making. Taglined the "Age of Big Data," we are becoming more and more reliant on data-driven evidence and analysis for nearly every decision we make. Data is not only becoming more available to the general public, it is also more understandable thanks to increased computing resources and advanced algorithms for analytics.

In utilizing Internet of Things (IoT) technology, utilities are now faced with the daunting task of making sense of the growing stack of data. Some utilities are finding more advanced, efficient methods of managing this data. By leveraging all the data generated at a utility (a truly big data set), utilities are able to provide rapid detection and response to operational events and gain valuable insight into their water distribution or wastewater collection system.

Challenges associated with increasing regulations, increased customer engagement, knowledge transfer for an aging workforce, and demands to do more with less are requiring the industry to change the way it is doing business. The purpose of the Water Blueprint is to demonstrate how utilities are leveraging IoT and Big Data to their advantage in addressing these daunting challenges.

About the Water Working Group

The Water Working Group was formed during the National Institute of Science and Technology (NIST) Energy/Water/Waste Supercluster Workshop in Atlanta, Georgia in March 2017, and comprises team members from Utilities, Technology Providers, Consultants, and Academic Institutions. The group continued to meet via conference calls following the Atlanta Supercluster Workshop to exchange information and share ideas throughout the development of the Water Blueprint document.

The Water Working Group comprises four focus areas: Water Quantity, Water Quality, Data Analytics, and Workforce of the Future. This Best-Practice Framework provides a discussion of the challenges, solutions, technologies, and tools in each of these four areas, as well as example case studies.

The audience and stakeholders for this framework include consumers/customers, City Managers and departments (including O&M, Public Health, etc.), water/wastewater agencies, business and commerce groups, citizen groups, environmental groups, resource agencies, regulatory agencies, and interagency groups, Center for Disease Control, etc.

Mission and Vision

The mission of every utility is to provide high-quality, safe water and wastewater services that provide a high level of customer satisfaction, and demonstrate environmental stewardship for their community. This can be best achieved by harnessing the power of innovative technologies and services, a best-in-class workforce, and a data-driven organization. This Water Best-Practice Framework provides guidance and examples for achieving utilities' missions and goals.

Strategies

The strategies that came out of the brainstorming sessions and Water Best-Practice Framework development for utilities that desire to create a smart water and wastewater system are captured below:

- **Strategic Plan and System Architecture.** Implementing technology solutions before developing a strategic plan and common system architecture rarely leads to a successful smart system program. It is critical to understand where you want to be in the future and the desired level of integration before implementing technology solutions that will end up in silos.
- **Leverage Success.** There is an all-too-common theme in the water and wastewater industry to pilot new technology and applications. The industry would move much quicker and reduce the cost of implementation by leveraging systems and applications already demonstrated by others.
- **Cultural Changes.** Adopting the use of IoT will require a cultural change for the majority of utilities. This will be similar to the cultural changes made by utilities for safety in the 1980s and security in the early 2000s. Change starts at the top, and senior management endorsement will be critical for success.

Summary of Use Cases and Deliverables

Throughout the discovery phase of the Best-Practice Framework development process, the team identified a large number of successful use cases using IoT to address critical challenges. These use cases were captured and are included here. Some of the critical challenges addressed in the case studies include:

- Protection of Distribution Water Quality and Public Health
- Reduction of Non-Revenue Water
- Reduction of Combined Sewer Overfows (CSOs) in a sewershed
- Improvement in Water Revenue Collection

Additionally, the team identified unmet challenges that can be addressed through the use of IoT and big data analytics and demonstration projects. These are captured at the end of each section.

Approach

The approach for preparing the Water Best-Practice Framework was a 4-step process:

- **Step 1.** The first step was conducted during the 2-day March 2017 workshop in Atlanta. Attendees that were interested in the Water Working Group met over the 2-day period and brainstormed about challenges, stakeholders, and attributes for developing a smart system. The brainstorming sessions covered the areas of water, wastewater, and stormwater. These areas were subdivided into four focus areas: Water Quantity, Water Quality, Data Analytics, and Workforce of the Future. At the end of the workshop, committees were created for each focus area and interested attendees assigned to each.
- **Step 2.** The second step was for the group as a whole to conduct monthly calls to accelerate information exchanges and idea sharing. To assist in the information collection process, a Sharepoint site was created for the Water Working Group.

- **Step 3.** The third step in developing the Water Best-Practice Framework was to have each focus area leader hold separate calls with their teams to continue developing and refining these sections.
- **Step 4.** The last step was to pull the four sections together into a single document in preparation for the NIST Global City Teams Challenge Expo. The document is not 100% complete at this time and remains a work in progress by the Water Working Group.

Common Terms Defined

Advanced Metering Infrastructure (AMI)	An architecture for automated, two-way communication between a smart utility meter with an IP address and a utility company.
Automatic Meter Reading (AMR)	Technology of automatically collecting consumption, diagnostic, and status data from a water meter and transferring that data to a central database for billing, troubleshooting, and analyzing.
Data Analytics	Statistical and mathematical data analysis that clusters, segments, scores, and predicts likely outcomes, compares the present scenario against previous scenarios, or classifies scenarios as anomalous.
Data Platform	Centralized computing system for collecting, integrating, and managing large sets of structured and unstructured data from disparate sources.
Energy-Water Nexus	The relationship between the water used for energy production, including both electricity and sources of fuel such as oil and natural gas, and the energy consumed to extract, purify, deliver, heat/cool, treat, and dispose of water and wastewater.
Interoperability	The ability of computer systems, software, and devices to exchange and make use of data, including those of different manufacturers.
Machine to Machine (M2M)	Wireless data communication between machines, generally using networks, especially public wireless networks.
Non-Revenue Water (NRW)	Treated drinking water that is lost in the distribution system before it can be delivered to customers.
Open Architecture	A type of computer or software architecture that is designed to make adding, upgrading, and swapping components easy (as opposed to closed, proprietary architectures).
Return on investment	Ratio of net profit or savings divided by total costs.
Stakeholder	A person, group, firm, or agency with an interest or concern in the outcome of a decision or process.
Sustainability	The ability to be sustained and supported long term without being harmful to the environment or depleting natural resources.

Available Resources

Additional information on best practices and IoT related to water and wastewater resources can be found in the publication of the following organizations.

- U.S. EPA Surveillance and Response guidance documents
- Smart Water Network (SWAN)
- Smart City Council – Readiness Guide
- Research foundations – WE&RF, WEF, GWRI, WSAA
- State Revolving Fund (SRF)

Water Quantity

Potential Stakeholders	Desired Contributions to the Solution	Desired Achievements/Goals
Consumers/Customers **Regulatory Agencies** **Resource Agencies** **Interagency Groups**	Water Production and Movement Storm water – CSO + SSO Meter Accuracy Non-revenue Water – leak detection, theft, inaccurate meters Pressure Management Water Conservation Infrastructure Replacement Hydraulic Modeling/Outage Management Regulatory Compliance Asset Management Long-term Maintenance	Future-proof 24-hour water supply Process improvement to match technology Environmental protection, reduced consumption Sustainability

Problems and Causes

The issues around Water Quantity are different depending on whether you are evaluating the water, wastewater or stormwater system:

- Water System issues include reliable delivery of clean water, reduction of loss associated with Non-Revenue Water (NRW), ensuring the sustainability of each community's water supplies.
- Wastewater System (Sanitary and Combined Sewers) issues include reliable collection and transmission of wastewater to prevent dry weather and wet weather discharges into the environment.
- Stormwater System issues include Adequately sized collection and transmission system to minimize flooding during extreme wet weather events.

Water System

It is a known fact that our planet's water supply is finite. There is as much water on earth today as there was yesterday, and as much as there ever will be. However, the human population continues to grow, and along with it the need for more fresh water. Further stressed by aging infrastructures, government mandates, and shrinking budgets, managing our planet's supply of fresh water continuous to be critical to ongoing economic prosperity and social wellbeing.

You've heard the phrase, *don't judge a book by its cover* and *it's about quality, not quantity*. Well, water quality can have a significant impact on available quantity. If there is plentiful supply, but its integrity is jeopardized in some way, for example by salt water intrusion, pollutants or algal blooms, the availability of clean, drinkable water is significantly reduced.

NRW is defined as treated drinking water that is lost in the distribution system before it can be delivered to customers. Worldwide, more than 32 billion cubic meters of treated water leak from urban water supply systems annually, equivalent to over $18 billion of NRW (source: Itron). Some of these losses,

such as leaks are easy to find, but many go undetected, resulting in precious treated water going to waste, lost revenues, and higher production costs. Additional losses associated with theft and poor metering result in lost revenue to the utility. Water losses on the customer side do not affect utility revenue, but they do have a negative impact on sustainable management of precious water resources. An increasing number of water providers are realizing that deploying new technologies such as acoustic leak-sensing across their distribution systems makes both economic and environmental sense. For example, a pipeline leak as small 1/8 inch can lose more than 3,500 gallons per day (gpd) until it is detected and repaired.

Ultimately, the biggest water challenge facing our planet today is the assurance that its most valuable resource can be sustained beyond tomorrow. Just because water resources in a particular area are not in jeopardy today, does not mean they will not be tomorrow. Increasing populations will continue to migrate to, and expect more from, water-rich areas. While Smart City initiatives are finding more efficient ways to sustain the drinking water resource, the demand is ever growing and fresh water supplies will only continue to be strained. The challenge is to ensure they do not become exhausted.

Solutions and Benefits

To meet continually increasing customer expectations, utilities must become more efficient in the way they manage their water resources, handle the demands of their service territory, and engage with their customers. The answer is not to decrease or limit access to fresh water, but rather to increase the efficiency with which water is provided and consumed – decreasing the excess not the access. In other words, to be “resourceful.” We need to understand how and when water is being consumed and/or lost so that decisions can be made today that will positively impact the sustainability of our water resources tomorrow.

This is done through data. But not just data and not just big data. It is through the effective collection of accurate, reliable data and the use of tools to analyze this data. The solutions to managing a community’s water resources include understanding the demands of a utility’s service territory; ensuring sufficient supply is available by more efficiently identifying contributors to NRW (such as system leaks, aging assets, and unauthorized usage); reducing operational expenses and uncovering new revenue streams; and providing customers with access to that same set of information so that they can understand and manage their consumption.

According to the U.S. Environmental Protection Agency (EPA), Water Efficiency is “the use of improved technologies and practices to deliver equal or better service with less water.” The key is access to products and solutions that deliver on that need, and equipping utilities to be able to minimize spending, increase operational efficiencies, and uncover new revenue streams.

Advanced Metering Infrastructure (AMI) and multi-purpose networks, in addition to optimizing the billing process, transform data collected through the system into valuable and actionable intelligence for users across the utility, delivering benefits to the entire organization from billing and customer service to operations, engineering, and distribution, empowering them all to address conservation and resource sustainable opportunities. Delivering the information necessary to make decisions enables a utility to effect change that will have both an immediate and lasting impact on the availability, management, and use of water.

A number of utilities and organizations are already demonstrating their commitment to water efficiency through the use of advanced technologies, implementing solutions that facilitate program objectives.

For example, Envision Charlotte in Charlotte, NC has programs in place to encourage the reduction of energy and water consumption in the downtown area of the city (known as Uptown). By bringing awareness to consumption levels through the deployment of advanced technologies capable of collecting hourly interval data, Envision Charlotte is encouraging change in the way energy and water are used and, as a result, showing that businesses can lower the expense of "keeping the lights on." A key benefit to this program is having more businesses come to the Charlotte area, and therefore more people. This is just one "end" justified by the "means" that demonstrates the power and flexibility of technology capable of satisfying utility challenges around the world.

The City of Madison, WI, thanks to the collection of interval data, was able to establish thresholds for identifying possible customer-side leaks, and then proactively notifying the customer. As a result of the City's efforts, the threshold for what alerts a possible leak has continually been lowered, or rather fine-tuned, over the past 3 years.

Another example of actuating change within a utility's operations and customer base is the City of Cleveland, OH. Following the implementation of an AMI, the City has also been able to proactively identify potential customer-side leaks and, in turn, proactively notify their customers. The resulting benefits have been recognized by both the utility and the end customer. Following notification from the utility, Cleveland Water's customers have the opportunity to minimize the impact to their water bill, and Cleveland Water has seen a significant decrease in the number of bill-related calls to their call center.

Furthermore, interval consumption data, coupled with the metered data from district meters, enables utilities to identify potential system losses through District Metering. System losses could be a result of leaks, aging meters, incorrectly sized meters, and/or unauthorized consumption. Having the ability to identify these potential losses prior to rolling a truck results is an immediate, positive impact to the bottom line.

Utilities that are challenged with drought conditions can monitor customer consumption to report on, and enforce, compliance during periods of water restrictions. Knowing when customers are using water, again without having to roll a truck, further decreases operational costs and increases the opportunities to save a valuable resource.

In addition to identifying system losses via the collection of time-synchronized data, with the installation of acoustical leak sensors, a utility can continuously audit the integrity of their distribution system. Knowing when leaks occur, before they damage public or private property, further decreases operational expenses and increases revenue opportunities. With proactive leak detection, utilities are able to reduce the amount of water lost, reduce the cost of repair, and as a result, reduce their NRW percentage.

Case Study: City of North Miami Beach, Florida

Overview: The City of North Miami Beach produces 21 million gallons per day (mgd) of water, delivered to 38,000 endpoints across 25-square-miles of Northern Miami-Dade County. The City's meter-reading and leak-detection process was labor intensive, time-consuming, costly, and inefficient. Until recently, the City relied on traditional walk-up, manual meter reading, and a leak detection service that visited quarterly to survey areas of its distribution system. Surveyors would visit for 2 weeks per quarter, helping City staff systematically go from one end of the 550-mile pipeline system to the other in 1-mile sections—requiring 1.5 years to get through the city's 25-square-mile service territory.

IoT Solution: The City is in the process of deploying an Advanced Metering Infrastructure (AMI) solution equipped with leak detection technology and cloud-based analytics. This system will deploy 38,000 communication modules along with 11,000 acoustic leak sensors, automating meter reading and leak detection simultaneously. The AMI system is providing real-time data on customer usage and potential leaks throughout the system, enabling the City to identify leaks within 3 days of occurrence. The result is significant savings in time, staff resources, treated water, and costs.

Benefit/Best Practice: With implementation of the AMI, North Miami Beach is able to enhance customer service, protect revenue, forecast consumption, analyze flow and support district metering by leveraging detailed consumption and meter alerts collected by Itron Analytics. The utility's customers have access to detailed consumption information through a secure customer web portal so they can better manage their usage, conserve water, and save money.

Case Study: Providence Water Supply Board (PWSB), Rhode Island

Overview: As the largest water utility in Rhode Island, PWSB supplies 60 percent of the state's drinking water, which includes wholesale distribution and 72,000 retail customer connections across 17 cities and towns. Renowned for its quality, Providence's water is sourced from surface water reservoirs fed by surrounding watersheds, necessitating a comprehensive management program to ensure purity and sustainability. With distribution system water loss of 11.6 percent, which is comparatively low by national standards, the utility sought to improve water conservation and operational efficiencies.

IoT Solution: PWSB chose automated meter reading (AMR) technology to detect leaks and identify needed repairs in the system. Deployment of 9,400 MLOG sensors and hosted mlogonline began in March 2010 and was substantially complete in May 2012. As of June 1, 2012 the utility was tracking 167 probable leaks. Leaks have been located on copper, lead, and cast iron lines and average about 3 gpm. MLOG deployment also led to the discovery of leaks on gate valves and hydrants, and field technicians have also discovered homeowner water theft and tampering made possible with "jumper" pipes or other types of meter bypasses.

Benefit/Best Practice: Competing priorities require utilities to constantly balance workload and resources. For Providence Water, the top two priorities are water quality and public safety; the third, at least recently, has been leak detection. Now that the utility has access to leak detection data and a trained crew to investigate and repair probable leaks, operations can better optimize its use of personnel and equipment. The utility's future savings in water production and treatment can in turn be used to fund other necessary infrastructure improvements.

Case Study:Town of Olds, Alberta

Overview: The Town of Olds Public Works and Utilities Department is responsible for maintenance of roads, the water distribution system, and the wastewater treatment plant for a population of just over 8,000. Approximately 10 years ago, the Public Works and Utilities Department determined that the town's NRW averaged nearly 40 percent, a startlingly high percentage with significant resource and financial implications. In October 2007, the Town formally endorsed a policy to develop and implement a water conservation strategy that included a goal to decrease total municipal water usage by 10 percent by January 2017 compared to 2006 usage.

IoT Solution: In 2010, the Town installed permanent acoustic leak sensors either indoors or outdoors on the water service pipe, usually near a water meter. These strategically placed acoustic sensors analyze sound patterns every day, detecting new, evolving, and pre-existing leaks automatically. A web interface — mlogonline Network Leak Monitoring System — interprets the data and analyzes the recordings and graphically displays all leak sensor locations using GIS and satellite mapping images, highlighting the status and location of leak locations using colored flags. Each "leak flag" prioritizes leaks as either probable, possible, no leak likely or sensor out of status. Over time, an expanding database of historical sensor information has provided a comprehensive condition assessment of the entire water distribution system. In the first 6 months since implementing the system, 21 leaks were repaired – recovering 287,691 cubic meters of water at a revenue savings of $177,336.

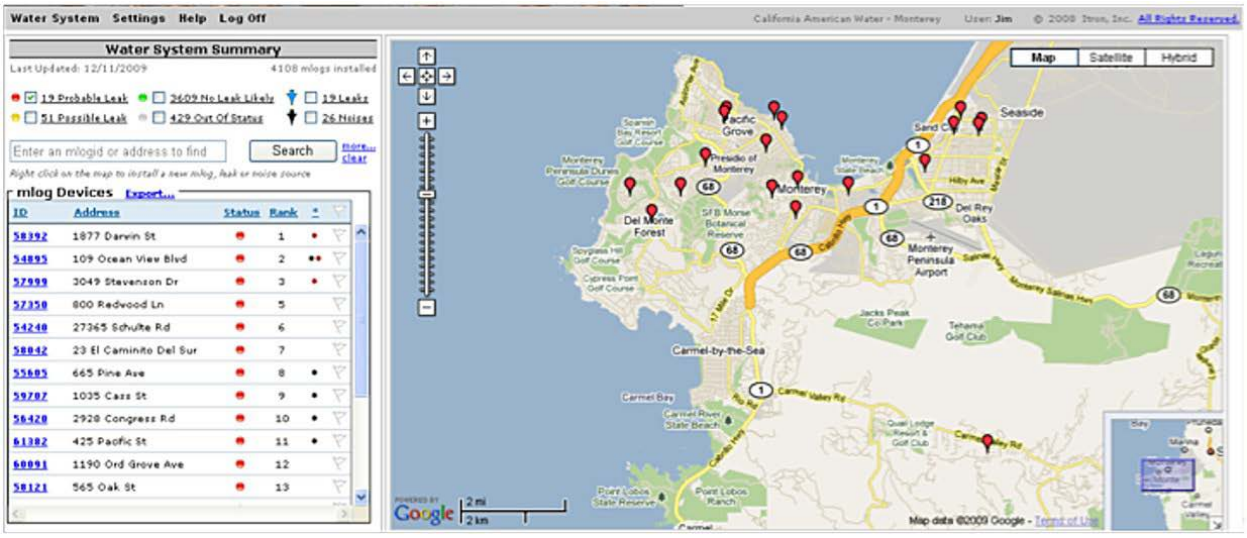
Benefit/Best Practice: The leak data analysis has helped the utility to target leak locations much more accurately, and targeted leak probabilities are linked to the GIS mapping interface, providing Town of Olds with a convenient visual representation of the parts of town where most of the leaks are occurring, along with details. This level of leak investigation translates into efficiencies, saving the Town of Olds repair expenses that not only validate their return on investment but also effectively advances their conservation objectives.

Case Study: California American Water, Monterey County

Overview: California American Water (CAW) is responsible for delivering water to Monterey County citizens by pumping more than two-thirds of its supply from the Carmel River watershed. A long-term local and statewide water supply emergency prompted the utility to invest thousands of hours and millions of dollars to protect the wildlife and habitat of the river. These efforts include stemming the loss of water loss through behind-the-meter leaks.

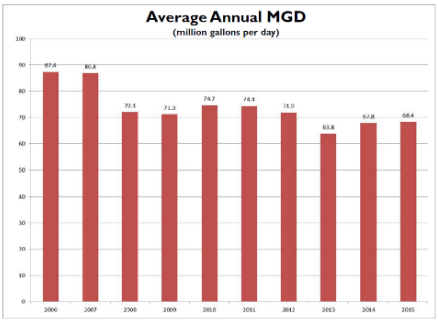
IoT Solution: Working with the Monterey Peninsula Water Management District, CAW set a goal to reduce its water loss from 9.5 percent to 7 percent. After evaluating its options, CAW installed a network of intelligent sensors in October 2008 that detect system leaks by measuring sound vibrations travelling down the pipes. CAW surveyors communicate with the sensors via radio frequency at a minimum of every 30 days, and often gather daily reads that coincide with meter reading. Once a week, the data is consolidated and then seamlessly uploaded to a web interface that ranks and visually maps identified leaks.

Benefit/Best Practice: Soon after deployment, the sensors identified many behind-the-meter (customer-side) leaks and 19 total leaks in the CWA system. The utility continues to reduce its water and revenue losses through this smart technology implementation.



Case Study: Gwinnett County Water Reclamation District, Georgia

Overview: The Gwinnett County WRD has a service area of approximately 68 mgd and 900,000 residents located northeast of Atlanta. While the WRD does not experience significant NRW in its distribution system, TBD.



Working with the U.S. EPA, the WRD is implementing an AMI pilot project with the primary focus of using smart water technologies to detect the root causes of NRW due to pipeline leaks and breaks, theft, and/or poor performing meters. Goals of the AMI pilot project include:

- NRW loss determinations – Number of faulty meters, theft occurrences, and pipeline breaks/leaks
- Improved system security – Ability to detect and rapidly respond to meter tampering and backflow occurrences
- Improved system resiliency – Improved response to pipeline breaks

- Cost Savings – Reduction in water losses from residential side of meter and pipeline loss reductions
- Value of water savings for both residential customers and Gwinnett County
- Staff Training – Development of response protocols and classroom training exercise

IoT Solution: Installation of the meters began in May 2017, and data collection will continue for 6-12 months after installation is complete. Technologies and data streams include residential and District Metering Area (DMA) AMI and residential and hydrant pressure sensors from a variety of vendors. Real-time data collected through the meters and sensors is analyzed through cellular-based technologies to identify and reduce NRW.

Benefit/Best Practice: Once completed, data from this pilot study will be shared with the EPA Water Security Division to evaluate its applicability to water security and resiliency. The project is funded by AT&T and Qualcomm for NRW and the EPA for resilience and security studies, with in-kind contributions provided as part of NIST's Global City Teams Challenge.

Water Quality

Potential Stakeholders	Desired Contributions to the Solution	Desired Achievements/Goals
Consumers/Customers **City Manager** **O&M** **Regulators** **Environmental Groups** **Public Health Department / CDC**	Water Quality SCADA and Data Analytics	Regulatory compliance (safe drinking water) Customer satisfaction PR / customer trust Environmental stewardship Adaptability Optimization

Issues/Problems and Causes

Common water quality issues/problems include contaminants such as Cryptosporidium, Giardia, and E. Coli; discoloration; turbidity; and lead. These water quality issues have a range of causes, both natural and manmade. Contaminants in the source water may be due to any combination of the following:

- Agricultural runoff
- Waste from wildlife such as ducks and geese
- Chemical spills
- Improper disposal of trash and waste
- Land clearing and other causes of soil erosion
- Stormwater runoff (SSO/CSO)

Water quality issues may also result from:

- Backflow and/or main breaks that introduces contaminants into potable water supply lines
- Weather and climate change – rainfall, temperature, and drought affect bacteria growth
- Lead in pipes, solder, and service line components
- Low chloride levels in areas of the water distribution system, allowing for bacteria growth
- Low pressure in areas of the water distribution system, which can allow contaminants to seep into pipes through cracks in pipes and joints

Solutions and Benefits

The range of solutions and their associated benefits are equally broad.

- Source water and distribution line sampling stations – proactively identify contaminant levels of concern. Potential opportunity to automate the stations with sensors and AMI/Smart Cities infrastructure technologies. Multi-head sensor technologies are available today that detect/measure +10 parameters from a single site installation.
- Remote Chlorine monitoring through sensor and AMI/Smart Cities infrastructure technologies at critical sampling points in distribution systems could provide a proactive approach to controlling bacterial growth and managing public notifications.
- Lead level monitoring of source water and critical distribution sampling points can be performed manually or remotely by using sensor and AMI/Smart Cities infrastructure technologies. Cast iron pipe replacement programs, use of only ANSI/NSF 61 certified water meters, valves, couplings and other potable water distribution system components is a common practice for cities to reduce lead levels in their water systems. Some utilities use chemicals to reduce lead or coat pipes to limit lead leaching into potable water.
- Other Water Quality parameters like pH, Turbidity, etc. can be managed manually or remotely by using sensor and AMI/Smart Cities infrastructure technologies to more frequent and proactive water quality monitoring to protect public drinking water and ensure customer/community satisfaction.
- Hydraulic modeling and Pressure management can equalize pressure across entire water distribution system reduces main breaks and. AMI/Smart Cities infrastructure technologies can provide timestamped meter readings for water districts or subdivisions to maximize the accuracy of the hydraulic models vs. use of historic usage data. Reducing main breaks preserves water quality by reducing opportunities for the entrance of contamination and promotes conservation of water.
- Remote/automatic PRV monitoring and control technologies can be used across water systems using that automatically adjust PRV's to systematically equalize water pressure at critical points and reduce main breaks. AMI/Smart Cities infrastructure technologies can provide the backhaul for these systems. Reducing main breaks preserves water quality by reducing opportunities for the entrance of contamination and promotes conservation of water.
- Distribution line leak detection sensor technologies coupled with AMI/Smart Cities infrastructure technologies can accurately identify water leaks in distribution lines and reduce main breaks by enabling utility personnel to proactively repair leaks before they break the

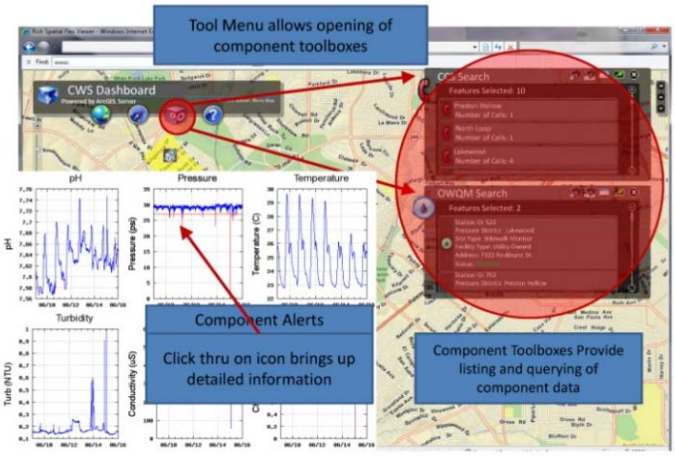
integrity of the pipe and cause a rupture. Reducing main breaks preserves water quality by reducing opportunities for the entrance of contamination and promotes conservation of water.

- Use of residential backflow devices on water meters or integrated residential backflow meters is common solution to protect against a siphoning effect occurring at a residential site pulling contaminants back into water distribution systems. Use of Smart Water Meters and AMI/Smart Cities infrastructure technologies can help utilities identify failed backflow devices and provide further protection against this public health threat.
- Sourcewater level and temperature sensors with AMI/Smart Cities infrastructure technologies can be used to monitor water levels during extreme weather periods to alert cities to associated water quality threats.
- CSO/SSO monitoring using sensors with AMI/Smart Cities infrastructure technologies can be used to proactively alert city personnel to critical sewer and waste water level conditions to divert flows or prepare for a hazmat situation. CSO/SSO monitoring has proven to reduce regulatory penalties/consent decrees.

Case Study: New York City Department of Environmental Protection (NYCDEP)

Overview: Under a grant from the U.S. EPA Water Security initiative (WSi), the NYCDEP installed a Surveillance and Response System (SRS) with the objective of enhancing existing water quality and real-time online monitoring, as well as improving customer response and consequence management.

IoT Solution. The SRS project included design and installation of 12 online water quality monitoring (OWQM) stations, integration of a consumer complaints system, design and installation of an extensive physical security system and development of a centralized spatial visualization and monitoring system. All data streams from the various components of the SRS are integrated and displayed through an electronic spatial dashboard.

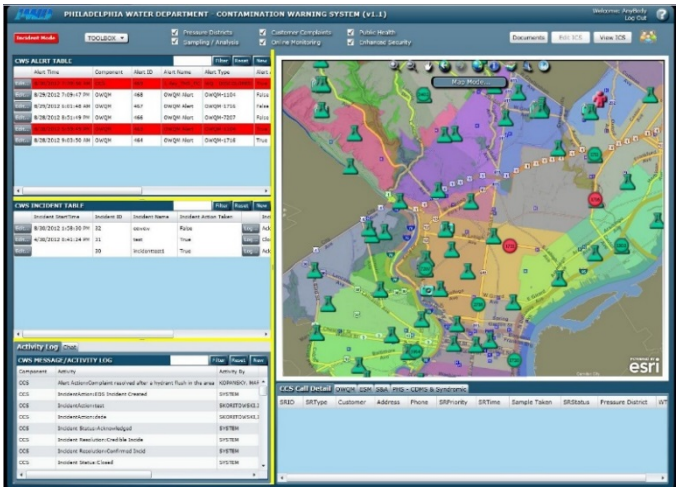


Benefit/Best Practice: Real-time data on water quality, consumer calls, and potential security threats is now available to NYCDEP staff through the SRS dashboard, improving information sharing and response throughout the Department. The SRS also leverages and builds upon existing NYCDEP programs and infrastructure to maximize sustainability and dual-use benefits.

Case Study: Philadelphia Water Department

Overview: Under a grant from the U.S. EPA Water Security initiative (WSi), the NYCDEP installed a Surveillance and Response System (SRS) with the objective of enhancing existing water quality and real-time online monitoring, as well as improving customer response and consequence management. The objective was to integrate multiple forms of surveillance and data streams through ICT to promote early and rapid detection of a water-supply contamination event.

IoT Solution: Major components of the SRS project included design and installation of 20 OWQM stations, integration of a consumer complaints system implemented in Citiworks, design and installation of an extensive physical security system, design and implementation of a centralized spatial visualization and monitoring system, and planning and execution of a full-scale exercise to practice the Consequence Management Plan. The ICT integration of these multiple information streams enables the detection of contamination events not indicated by any individual system component.



Benefit/Best Practice: ICT integration of multiple data streams ensures a safe and secure water supply. The GIS-based dashboard allows the underlying component data streams to be visualized spatially. The

ICT system components help to streamline and improve operations under routine conditions, and facilitate the detection of more-routine water quality problems, water main breaks, or source water quality issues. The ICT also eliminates the need for duplicate data entry and manual processing.

Case Study: Dallas Water Utilities

Overview: Dallas is one of four U.S. cities that received a grant from the U.S. EPA Water Security initiative (WSi) to implement a Surveillance and Response System (SRS) demonstration pilot project. The goal of the project was to develop protocols to protect the drinking water system from intentional or accidental contamination and to identify the contamination as early as possible to further protect public health and safety, with the results being used to develop industry best practices for utilities to use across the U.S.

The project explored innovative technologies, including various sensors, multiple disparate data sources, data aggregation, and visualization of the data. The data visualization, in particular, used innovative methods to provide operators with spatial and temporal trending of large data sets from all available data sources.

IoT Solution: The SRS project included the design and installation of 16 OWQM stations, 15 of which were connected to the network using 4G cellular connections; integration of a consumer complaints system implemented in SAP; integration of public health data from the Tarrant County Advanced Practice Center; design and installation of an extensive physical security system; design and implementation of a centralized spatial visualization and monitoring system; and planning and execution of a full-scale exercise to practice the Consequence Management Plan.

Benefit/Best Practice: TBD.

Case Study: San Francisco Public Utilities Commission

Overview: San Francisco is one of four U.S. cities that received a grant from the U.S. EPA Water Security initiative (WSi) to implement a Surveillance and Response System (SRS) demonstration pilot project.

The purpose of the pilot project was to develop and implement processes to detect a broad spectrum of contaminant classes, achieve spatial coverage within the distribution system, detect contamination in sufficient time for effective response, reliably indicate a contamination incident with a minimum number of false positives, and provide a sustainable architecture to monitor distribution system water quality.

IoT Solution: The SRS project included siting, design, and installation of 10 OWQM stations using the Threat Ensemble Vulnerability Assessment and Sensor Placement Optimization Tool (TEVA-SPOT) hydraulic modeling tool to identify optimal station locations and researching and evaluating multiple

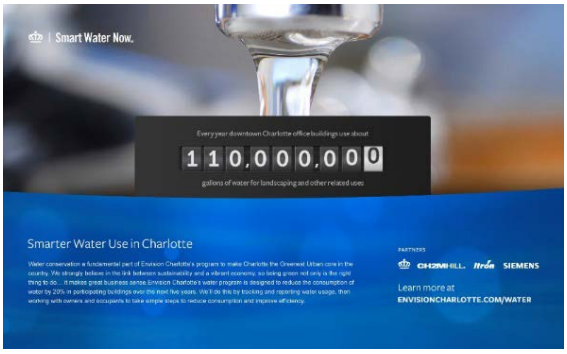
OWQM sensors for specific features, reliability, and ease of maintenance. Additional project components included:

- Design and implementation of a centralized spatial visualization and monitoring dashboard system
- Further development of the consumer complaints system and integration of the system and the Laboratory Information Management System (LIMS) into the dashboard
- Procurement of specialized laboratory equipment and development of procedures and associated documentation to decrease response and analysis time, maximize the number of contaminants that could be identified, and increase in-house analytical capabilities
- Preparation of police educational awareness videos to enhance understanding of water facilities security requirements by these first responders
- Development of a rapid query system to enhance the ability to investigate and respond to waterborne contamination and improved cross-jurisdictional coordination during response
- Planning and execution of a comprehensive full-scale exercise to practice response actions and evaluate the usefulness of the Consequence Management Plan

Benefit/Best Practice: TBD.

Case Study: City of Charlotte, North Carolina

Overview: The City of Charlotte sought a system-wide, full-cycle infrastructure integration and communication solution for its uptown energy and water consumption, air quality, and waste reduction. The resulting program, Envision Charlotte, is a groundbreaking public-private partnership (PPP) supporting the City's vision to achieve economic growth through environmental sustainability. The program comprises four pillars – Smart Energy Now™, Smart Water Now™, air, and waste – with the ambitious goal of achieving a 20 percent reduction in the use and related costs of energy, water, air, and waste.



IoT Solution: Through Envision Charlotte, building data is monitored, aggregated for the urban core, and reported to building managers, occupants, and the public so they can see a more direct link between their daily business and personal activities and the related impacts on energy and water use. The program has provided a platform for collaboration among government, businesses, and citizens who share Envision Charlotte's dual goals of economic prosperity and civic sustainability.

Smart Water Now™ is centered on smart water grid technologies – connecting with the energy grid – to help the City achieve its goal of a 20 percent reduction in water consumption. That equates to about 53 million gallons of water — or enough to fill 80 Olympic-size pools. Using smart water grid technologies, an automated metering infrastructure (AMI) system was implemented that provides aggregated water consumption information to building managers, occupants, and the public – supporting Charlotte's goal to be a global model for smart cities.

Smart Water Now's™ integrated virtual data-sharing technologies have maximized community involvement and established a global model for environmental sustainability and measureable community results. These technologies include:

- Digital grid technologies to display near real-time water data in uptown Charlotte, create broader awareness of the program's progress, and promote behavioral change to support further progress.
- Smart meters to capture the water consumption of each building and upload it to the cloud as encrypted data for network sharing.
- Video screens in building lobbies to show real-time total water used by business district buildings.
- Cloud-based aggregation and analyses of water usage to enhance water optimization with utility and smart grid technologies.
- A network and data-sharing template for future smart city applications.

A Smart Water Now™ web portal was created that enables real-time sharing of data related to community performance in water consumption. The web portal enables building occupants to track the city's progress on smart phones and online. By providing data in intuitive ways – trending, benchmarking, or correlating with other data sets – program participants are better able to assess how they can build, operate, and live smarter.

Benefit/Best Practice: Envision Charlotte and Smart Water Now™ created measurable improvements in City-wide sustainability and awareness and the related reduction in water costs to the community. Uptown building managers and occupants have access to near real-time water usage, resulting in identification and incentivization of water efficiency measures. The program has also enhanced Charlotte's image as a progressive city, helping attract new business and strengthen its economic base.

Case Study: Metropolitan Sewer District (MSD) of Greater Cincinnati

Overview: The MSD's wet-weather assets are spread across its 300-square-mile service area. Minimizing wet weather overflows from its decentralized facilities – many with critical dependencies on other wastewater collection and treatment assets – required an innovative solution that would enable MSD to manage entire watersheds like operators manage a treatment plant.

Starting in the late 1980s, the Federal government, through the Clean Water Act, called for the elimination of Sanitary Sewer Overflows (SSOs) and reductions in Combined Sewer Overflow (CSO) discharges. This initiative affected every wastewater system in the country, including the MSD, where the age and design of the system contributed to increased scrutiny and enforcement, as well as heavy civil penalties for noncompliance. In 1999, while MSD had already begun addressing the requirements, costs to customers were a significant factor in entering into negotiations with the U.S. EPA, Department of Justice (DOJ), and State of Ohio to develop an acceptable formal remediation program.

IoT Solution: The MSD worked with a technology consultant to evaluate and implement a distributed system of smart sensors, multi-mode communication through IoT devices, and integration of data streams from disparate sources throughout the watershed – including remote wet-weather storage and treatment facilities, stand-alone flow meters, level sensors, and rain and stream gauges. The resulting Smart Sewer system provides MSD with near real-time visualization of conditions throughout the system and control of critical wet-weather functions, thereby reducing CSO events and associated costs.

The smart sewer solution uses real-time data collection and analytics, along with cloud technology, enabling MSD to visualize flow conditions in the entire system in near real time and achieve greater system performance during wet weather. With mobile access and intuitive SCADA screens, operators can navigate the system and immediately access monitoring data and make operational adjustments from any location. An integrated GIS dashboard enables management to have performance data at their fingertips and supports regulatory reporting requirements at the push of a button. With 6,058 SCADA tags, the integrated system is the most sophisticated of its kind.

Benefit/Best Practice: MSD now has watershed-level control of facilities and improved operational decision-making. The data-driven system also enables MSD to increase its readiness before a storm hits through better maintenance, and to improve its performance during wet weather using predictive and alerting algorithms.

- Connects wet weather assets with other infrastructure systems across the city, enabling MSD to manage its watersheds with the click of a mouse
- Enhances reliability and readiness before, during and after wet weather events
- Provides operations staff with the ability to view multiple data streams in real time from a single location
- Creates actionable information that staff can easily understand and use as the basis for rapid detection and response
- Allows staff to access key information and make decisions anytime, anywhere and on any device
- Streamlines regulatory reporting and compliance

Data Analytics

Potential Stakeholders	Desired Contributions to the Solution	Desired Achievements/Goals
Operator/End User **Customer Service Rep** **IT Department** **Resource Conservation Manager** **Innovation Officer** **Engineering/Planning Department** **O&M Staff** **Tech Providers and Universities** **Flood Control District**	Predictive Maintenance Adaptability SCADA/Data Analytics Interoperability/Data Platform/Sensors + Software/Open Architecture Billing + Customer Service Customer Engagement (Social Media) Data Security – Openness/Privacy Cross-Department Integration Sharing of Network Assets	Open architecture data framework Secure data Accurate data Actionable information Timely data Improved operational awareness

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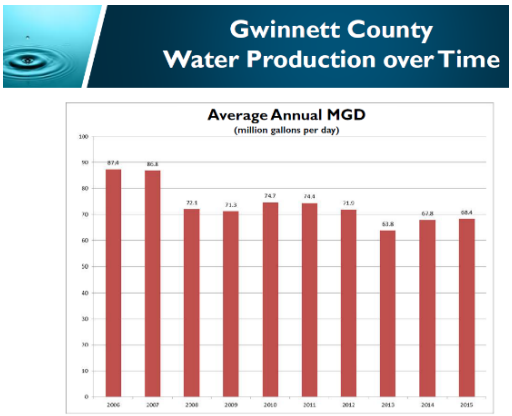
Case Study: Gwinnett County Water Reclamation District, Georgia



Overview: The Gwinnett County WRD has a service area of approximately 68 mgd and 900,000 residents located northeast of Atlanta. While the WRD does not experience significant NRW in its distribution system, TBD.

Working with the U.S. EPA, the WRD is implementing an AMI pilot project with the primary focus of using smart water technologies to detect the root causes of NRW due to pipeline leaks and breaks, theft, and/or poor performing meters. Goals of the AMI pilot project include:

- NRW loss determinations – Number of faulty meters, theft occurrences, and pipeline breaks/leaks
- Improved system security – Ability to detect and rapidly respond to meter tampering and backflow occurrences
- Improved system resiliency – Improved response to pipeline breaks
- Cost Savings – Reduction in water losses from residential side of meter and pipeline loss reductions
- Value of water savings for both residential customers and Gwinnett County
- Staff Training – Development of response protocols and classroom training exercise

IoT Solution: Installation of the meters began in May 2017, and data collection will continue for 6-12 months after installation is complete. Technologies and data streams include residential and District Metering Area (DMA) AMI and residential and hydrant pressure sensors from a variety of vendors. Real-time data collected through the meters and sensors is analyzed through cellular-based technologies to identify and reduce NRW.

Benefit/Best Practice: Once completed, data from this pilot study will be shared with the EPA Water Security Division to evaluate its applicability to water security and resiliency. The project is funded by AT&T and Qualcomm for NRW and the EPA for resilience and security studies, with in-kind contributions provided as part of NIST's Global City Teams Challenge.

Workforce of the Future

Potential Stakeholders	Desired Contributions to the Solution	Desired Achievements/Goals
HR Department **Operations Manager** **Universities + VoTech – Curriculum for Data Engineers** **Executive Staff** **General Workforce**	Transition from Legacy Systems Aging Workforce Training and Process Improvement Cultural Acceptance SCADA/Data Analytics	Employee satisfaction Employee retention Well-trained staff Cross training

Issues/Problems and Causes

Under development.

Solutions and Benefits

Under development.

Case Studies

TBD.

Summary of Best Practices

Under development.

Requirements for Implementation

Significant requirements for a City to implement the ideas presented in this Best-Practice Framework include:

- Trained workforce
- Funding – bonds, rates, private money
- City champion in a position of authority
- Strong business case – quantitative, qualitative, metrics
- Tiered goals – short-term and long-term
- Community support / Outreach program
- Vision for an integrated system, including common architecture
- Measured baseline
- Employee cross-training, buy-in, and education (address fear of job loss)
- Adoption of new business model (managed services, etc.) (NaaS, SaaS)

Reflecting on these city requirements, the major barriers/challenges that cities may face and their possible solution and milestones are summarized below.

Barrier/Challenge	Proposed Solution	Milestones and Metrics
Funding – services versus rates	Create a strong business case Look at private funding and alternative revenue streams	Short-term (0-12 months) – need financing in place; tiered over time
		Demonstrated 3- to 5-year ROI (economic analysis)
Union Objections	Emphasize resource reallocation – retraining and education as needed	Short- to mid-term (2-4 years)
		Negotiated contract
Public Relations and Politics	Create a strong business case Show benefits to public (happy customers/constituents = legacy) Leverage city-to-city competition Economic development Partner with local universities Leverage disasters (Ex: floods, Flint, MI)	Short- to mid-term
		Reelection Constituent feedback – 90% customer satisfaction Positive press releases Regional rating system
Commitment to Legacy Systems	Create vision for new technology system Demonstrate strong ROI to justify change	Long-term
		Positive ROI
Fear of New Technology –	Show benefits through demonstration projects	Short-term – before implementation

Operations versus IT Staff	Ensure open access systems, transparency Open architecture	90% employee satisfaction (survey) Proof of safety
Complexity of Systems	Embed human intelligence and manual backup options	Mid- to long-term
	Open source / open architecture Rollout systematically in steps Provide managed services	Operational success Maintenance savings in FTEs
Skillsets at All Levels	Train workforce – need more data engineers and data scientists	Mid- to long-term
	Include cross-function team in decision-making and implementation Provide managed services	Employee retention; < 3% turnover Projected vs. actual costs for managed services
Regulatory Requirements	Align internal standards with mission statement	Mid-term
	Regulatory relief with Federal agencies	Reduced number of violations and associated costs/fines – pre- vs. post-installation
Lifecycle Costs of IT Systems	Decouple hardware and software for staggered maintenance/replacement	Long-term
	Decouple sensing and communication Transition to edge to processing	Projected to actual hardware and software costs

Looking Ahead

Under development.

Future topics and areas for growth include collaboration and planning, real-time data collection and sharing, better/actionable and in-house data analytics, interoperability, inter-related sensors, and transition of legacy systems.

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Ven Balaga	City of Atlanta
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David Logsdon	X
Jeff Lyall	AT&T
Carlos Mosqueda	Driblet Labs
Subodh Nayar	Nayars
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WASTE WORKING GROUP FRAMEWORK BEST PRACTICES

Innovative might not be the first word that comes to mind when one thinks about the waste management industry. However, most do not typically think about a city's responsibility to pick up the discards that we place curbside once or twice a week, to remove whatever we place in public cans, to clean the mounds of trash that fill our streets after special events -- each action to be completed within an expected timeframe. When a pick up is missed at our homes or when street cans are overflowing, or when we see and smell the debris left by fans the morning after our local team wins the championship littering the streets, we blame the city for not doing its job. Private sector contracts for service are based upon the frequency of pick-ups that need to be made, regardless of how full a container might be at any given time. Rarely, do we care about how much waste we generate or about what happens to the materials once they are tossed.

Compound this issue of waste with the battle to attract customers through shelf appeal which creates layer upon layer of unnecessary packaging materials that require disposal. Shiny is better, we are taught. If our product is bigger and faster than our competitors' we will achieve success. This means that in addition to the raw materials used to make a product, we are using more raw materials to package, ship, and display products. Then, we throw it away with little thought beyond keeping an area tidy. Our pattern is a "take, make, and dispose" linear economy.

However, we are beginning to understand the long term effects of our behavior and how completely unsustainable our actions have been. To address this issue, a shift is taking place towards a more coordinated approach that emphasizes recovery, reuse, repair, and recycling. Unfortunately, there are systemic barriers that are present and built into the current linear economy that challenge progressive methods for waste management. Opposition by vested interests and legacy laws and regulations that support our careless habits which provide no value to what is being discarded. Thankfully technological solutions are being applied to offer an improved understanding and ability to change our course and find opportunities for efficiencies that will provide greater value in the thoughtful and innovative removal of waste.

About the Waste Working Group

The Waste Working Group will officially begin online in the Fall of 2017. There group's areas of focus will be:

- Managing Organics
- Efficient Operations
- Embracing the Circular Economy
- Data and Reporting

The Working Group is seeking an individual or organization to take the lead in one areas well as an individual who would assume the leadership and provide direction for Waste Working Group.

Mission and Vision

The purpose of this group is to champion and accelerate the coordinated advancement of the use of technology, data, and analytics to assist municipalities in the achievement of Zero Waste goals, as well as realize the economic, environmental, and societal benefits that are possible through the transformation from a linear to a circular economy.

Summary of Action Clusters and Common Use Cases

The waste related projects that have been developed as Global City Teams Challenge (GCTC) Action Clusters all point to a need to address multiple inefficiencies in waste management. There have been eight GCTC projects that have focused on the issue since the start of the original Smart America by the National Institute of Standards and Technologies (NIST). Seven of those eight projects have used web-based sensors that generate near real-time information about the fill levels of waste containers as the foundation of their projects. Those seven projects have all identified or developed software that integrates with GIS to assist in the analysis and interpretation of the new sensor data so as to provide quality insights on how to;

- Avoid overflowing bins by providing alerts
- Learn to use personnel more efficiently,
- Optimize service routes dynamically,
- Relocate underutilized receptacles
- Reduce operating costs and generate reports

The projects that reached and reported on the post implementation stage of their pilots all claimed a perceived level of success. The pilots reported perceived levels of success rather than actual because of the lack of the baseline data that would be needed to verify success. There was an additional variation in perceived success that ultimately was identified as reflective, not of differences in the technologies used, instead they reflected the level of buy-in of the field workers and the level of prioritization the pilots received from senior management.

When projects from outside the GCTC data set were included, the immediate realization was that the United States has lagged behind Europe and Asia in regard to implementing a set of smart solutions to waste management, actions successfully deployed in numerous cities in those regions years ago. The analysis of all known GCTC implementations from around the globe identified that pilot projects (25-100 sensors), while effective, did not demonstrate the same levels of efficiencies and savings as were produced when the implementations were done at scale, (500+ sensors) and across much larger service areas.

The perceptions study identified additional factors that project leads believe impacted results. These factors include:

- Industry reluctance to change operations
- Regulations that prioritize quick removal
- Uncertainty in choice of business model

Within the individual pilots, there were several unique elements in which additional technologies and approaches were utilized. One pilot used smart bins that included the ability to compact the waste contents using a solar power source. Another included the ability to weigh the content of the bins through the inclusion of scales in the base of the unit. And another pilot used a cell phone application to document the fill levels of bins prior to the installation of sensors. The consensus of the responses has shown that the use of fill level sensors and analytic software to improve the efficiency of waste management is an improvement and its usage will accelerate across the United States as awareness of the successful deployments spreads.

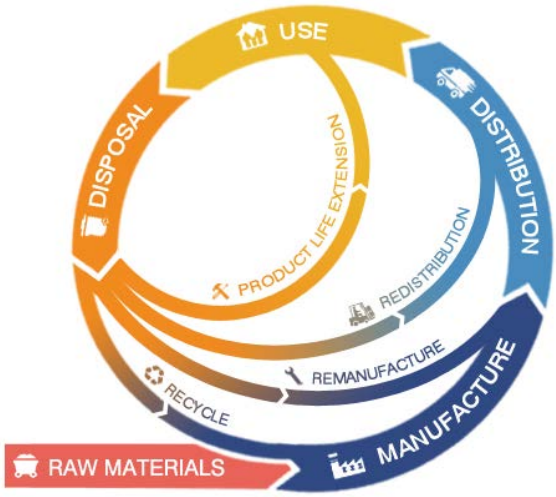
However, there still remained uncertainty as to what the best business model will be, now that the time periods for the pilots are expiring. There are more than a dozen waste management companies actively competing for municipal "smart bin" contracts nationally, with only subtle differences between the technologies being offered. The first city-wide deployment at scale in the United States will be the City of Pittsburgh that has chosen a vendor to deploy over 1,200 smart bins citywide. Data collected from its 95 smart bin pilot study has projected that by expanding the program the city will be able to reallocate 15,000 man hours to meet other pressing needs.

The Future of Smart Waste Management

Solid Waste Management IoT Solution, one of the seven action cluster projects that is being implemented in South Bend, Indiana and Pune, Mahashatra in India is the only project that looks at the possibilities that extend beyond the optimization of the operational status quo. Their project is aspiring to apply technology and data analytics to monetize an otherwise stranded value embedded in the materials being collected as waste. The goal is to use the data collected and analyze to optimize the distribution of recovered materials, ultimately to anticipate future markets for those waste materials; establishing new partnerships that provide innovative products that have yet to be imagined. This model, which is known as the circular economy, had been more theory than reality, until now. Real world implementations are now being realized across the globe, that through a systematic application of technology and artificial intelligence have the potential to take the circular economy to scale.

The Ellen MacArthur Foundation defines the circular economy as an economic system where products and services are traded in closed loops or 'cycles'. A circular economy is characterized as an economy which is regenerative by design, with the aim to retain as much value as possible of products, parts and materials. This means that the aim should be to create a system that allows for the long life, optimal reuse, refurbishment, remanufacturing and recycling of products and materials. The Circular economy requires an understanding of f **system thinking**, where all actors (businesses, persons, organisms) are part of a network in which the actions of one actor impact other actors. In a circular economy, this is taken into account in decision making processes by including both short- and long-term consequences of

a decision, considering the impact of the complete value chain, and aiming for the creation of a more resilient system which is effective at every scale.



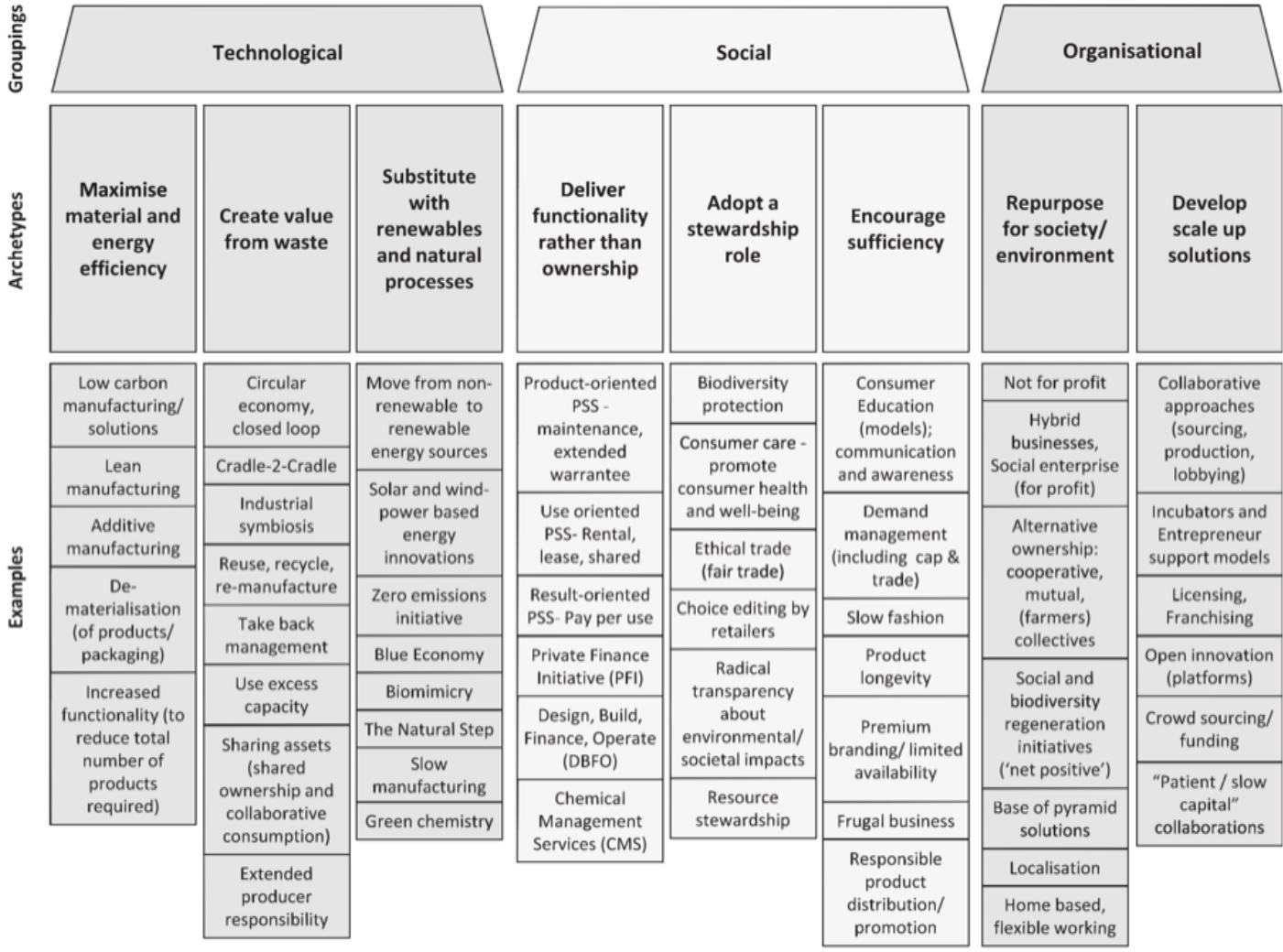
The focus on sustainability by all sectors has increased to a level where sustainability metrics have become an important evaluation criteria for decision making. The circular economy is the natural and logical next step to sustainability. The efficiencies and cost reductions are clear and identifiable, however it's the value creation and ability to innovate at a system level that makes the circular economy so compelling. A number of factors exist that will drive the transition that is needed.

The four most important of those drivers are:

- The positive business case
- A scarcity of certain of resources
- Climate change impacts, and
- New opportunities to innovate

Towards a Circular Economy: Business Rationale for an Accelerated Transition is the executive summary of analysis conducted to by the Ellen MacArthur Foundation regarding the benefits that could be realized by decoupling global economic development from the consumption of finite resources. The arguments are similar to those made when the sale of electricity was decoupled.

Incorporating circular practices requires collaboration across multiple companies in order to modify operations and be able to capitalize collectively when new opportunities emerge. Collaboration is not always easy and usually causes delays that can be costly. However, successful collaborations can also provide much greater returns when successful. The most successful collaborations are those that expand the combined range of services provided, with little or no overlap between partners. The chart below provides a glimpse of the complexities and details that are possible.



The Netherlands – A Leadership Model to Emulate

A complete and systematic overhaul of infrastructure and policies is required to be able to transform a linear economy into one that is circular at a city level. As daunting as that may seem, there are examples where those transformations are rapidly occurring. A strong case for this conversion can be seen by examining the systematic implementation of changes that has been underway in the Netherlands, one of the early champions of the Global City Teams Challenge.

The Netherlands has long been recognized as a country of innovation; it's part of their international brand. The leadership of the country has positioned the Netherlands as a circular hotspot by taking bold and "SMART" actions that inspire their people to participate in programs where they can reap the benefits.

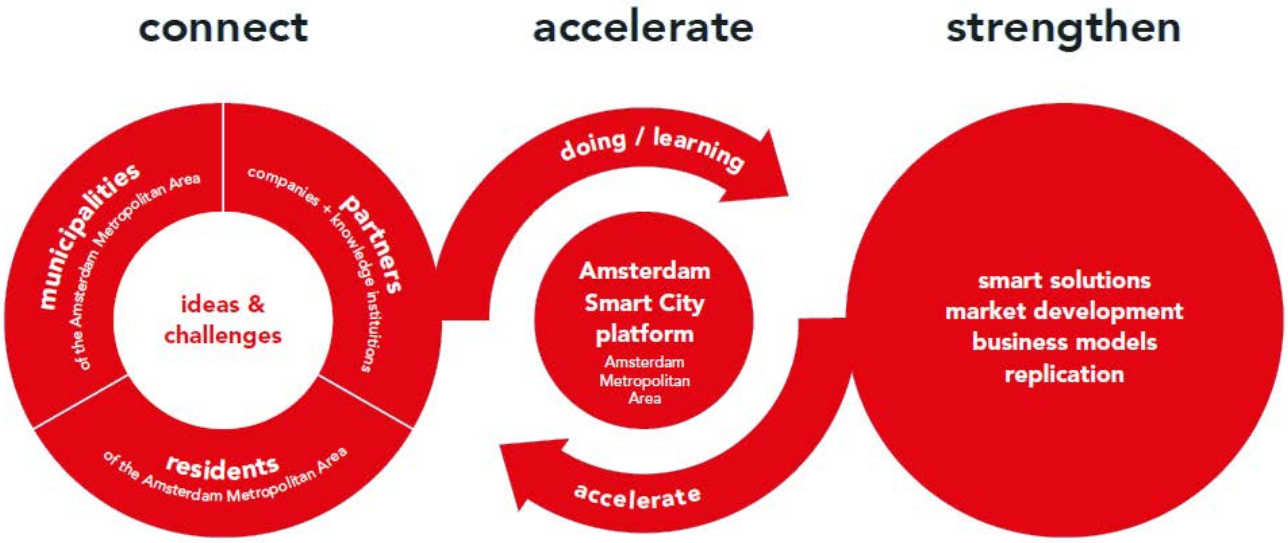
The Netherlands has defined their region as a "living lab" for Smart Cities and the circular economy. A place that serves as a role model for rest of the world. As a frontrunner in the circular economy they are creating the benefits for both the Dutch economy as well as the society as a whole.

A large team of representatives from the Netherlands, including the King and Queen, participated in the inaugural Global City Teams Challenge Expo in 2015 that was held at the National Building Museum in Washington DC. While the attendance of royalty was an individual highlight of the Expo, it was the comprehensive integration of innovation and leadership they showcased across their multiple booths that was the most impressive aspect that year.

Amsterdam Smart and Circular City

Amsterdam Smart City (ASC) is an example of an innovation platform for any future city. The platform allows them to constantly challenge businesses, residents, and knowledge institutions use the municipality to test innovative ideas and solutions to address urban issues. This contributes to the livability of the Amsterdam Metropolitan Area, promotes sustainable economic growth and helps develop new markets.

Amsterdam has six different active themes in which they bring together different organizations to start innovative projects together.



Amsterdam Smart City has created a smart city innovation platform to facilitate the creation of an overview of what is happening across the six interrelated themes. The platform lets leadership connect the right people needed to accelerate the implementation of projects across the city. The overview of their ecosystem also connects them to the global community who they can share their expertise with while challenging those external parties to submit and execute innovative solutions that address the urban issues in Amsterdam. Amsterdam Smart City advances the development of new markets and profits for innovative solutions.

Intelligent Assets: Unlocking the Circular Economy Potential:

This report is a powerful illustration of the opportunities for innovation and creativity across the full spectrum of smart city industries and sectors that exist at the intersection of the circular economy and the smart devices that make up the Internet of Things. The report is the product of Project MainStream, an initiative of the World Economic Forum, the Ellen MacArthur Foundation and McKinsey & Company.

The Netherlands Circular Hotspot is the campaign The Netherlands designed to leverage the the Dutch presidency of the EU in 2016. Prince Carlos de Bourbon de Parme (INSID) and Circle Economy, an Amsterdam based non-profit that aims to accelerate the transition from a linear to a circular economy, by supporting individuals, companies and organizations, collaborated with a diverse group of decision makers and visionaries to discuss how the Netherlands could inspire governments and international businesses to take action. The elements of the campaign they created were:

- **Innovation Expo:** During this international event, business leaders, scientists, students, policy makers and journalists connected to inspire each other on sustainability in urban areas.

- **Circular Expo:** This exhibition showcased the techniques and ideas that were developed to keep the planet healthy. The exhibition stimulates participation in the transition to make the circular model the norm.

- **Incoming Trade Mission:** The Netherlands brought visitors together and show the intellectual capital they could offer to other countries. The mission took visitors to several Dutch regions with active projects.

  The Sustainability Fund: The City of Amsterdam established a sustainability fund offering financing (in the form of loans, backing or equity capital) to sustainable projects initiated by Amsterdammers. The fund is available for everyone in the city, from sustainable start-ups to major commercial ventures.

  Circular Buiksloterham: Buiksloterham is a unique neighborhood within Amsterdam that serves as a living lab for Circular, Smart, and Bio based development. Over the coming years, Buiksloterham will develop into a sustainable district, based on circular principles. It will be up to the project partners in Buiksloterham to determine the particular issues that need to be solved.

- **Zero Waste Lab:** De Gezonde Stad (the Healthy City) opened the first Zero Waste Lab in the Netherlands: a neighborhood lab for social & circular innovation. Amsterdam residents hand in their separated waste and get value coins in return. These can be spent in shops in the same area. The waste is upcycled and recycled. The Zero Waste Lab is also a training center where residents are trained as experts in raw materials, in cooperation with the organization De Regenboog Groep.

- **Cases and Iconic Projects**: There are many impressive and inspiring circular examples of cities, ports and businesses within The Netherlands, which we will share with the rest of the world in order to inspire the international community in their transition towards circular models. The Cases and Iconic Projects will be shared on this website, social media and in the magazine

Acknowledgements

The Waste Working Group would like to acknowledge and thank the following people whose contributions of time, expertise, and knowledge contributed to the development of this Best-Practices Framework.

NIST Global Cities Team Challenge (GCTC)
Utility SuperCluster Working Group
Best Practices Framework for Sustainable Energy, Water and Waste Solutions

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Lydia Charles	Wild Canary, LLC
Ramesh Jain	Krumbs
Andrew MacLeod	City of Edinburgh
Anca Novacavici	Eco-Coach
Brenda Pulley	Keep America Beautiful
Brian Pompeo	Enevo
Emma Skalka	Victor Stanley
Michael Son	Ecube Labs
Eswaran Subrahamian	Carnegie Mellon
David Troust	Great Forest
Charlie Whitaker	CareerPath DC
Annie White	DC Dept. of Public Works

Summary of Actions Clusters

1) Action Cluster: IoT Based Waste Management System - Smart Garbage Monitoring System (SGMS)

- **Municipal Governments**:

  i) City of San Leandro, CA

- **Members:** Santa Clara University,

  i) Dew Mobility,
  ii) IBM,
  iii) Intel;
  iv) San Leandro Chamber of Commerce;
  v) San Leandro Improvement Association (SLIA)

- **Team Leads:**

  i) Shivakumar Mathapathi,
  ii) Prof. Vasu Kadambi

- **Description:**

  i) SGMS is a real-time indicator of the level of trash at any given time in a Garbage Can. A unique identification number (ID) is given to each can. As soon as the Garbage Can is full/ overflowing then a SMS is sent to the server from where all the garbage collection vehicles are allotted. SGMS hopes to optimize waste collection routes and ultimately reduce fuel consumption by enabling trash collectors to plan their daily/weekly pick up schedule.

- **Project Status:**

  i) Ready for pilot implementation

2) Action Cluster: Smart Waste Management & Logistics for Municipal Solid Waste Collection Operations

- **Municipal Governments**
  - **i)** Goyang City, Korea,
  - **ii)** City of Los Angeles CA,
  - **iii)** City of Chula Vista, CA,
  - **iv)** City of Hermosa Beach, CA,
  - **v)** The District of Columbia

- **Members:**
  - **i)** Ecube Labs,
- **Team Lead:**
  - **i)** Michael Son
- **Description:**
  - **i)** Participating municipalities stated a desire to achieve more efficient use of personnel and resources as well as reducing citizen complaints as reasons for their participation in the Ecube Labs pilot studies. Ecube Labs takes each city through a process of assessment, deployment, analysis, and adjustment utilizing their resource management platform to optimize the efficiency across the waste collection value chain. Their cloud-based software solution provides monitoring and analysis of the collection reports and data from transmitting sensors, to extract actionable insights.
- **Project Status:** Status of the pilots range from:

i) Early stage (Chula Vista, Los Angeles)
ii) Mid-stage (Washington DC)
iii) Late Stage (Goyang City, Hermosa Beach)

3) Action Cluster: Recycling bin monitoring system and optimization of pick up schedules for City of Safety Harbor

- **Municipal Governments:**

  i) City of Safety Harbor, Florida

- **Members:**

  i) Litmus Automation;
  ii) Kyra Solutions

- **Team Lead:**

  i) John Younes

- **Description:**

  i) The City of Safety Harbor has challenges with trash bins overflowing from too many cans or bottles that are put into bins during busy times in congested areas. Also, there are instances in which the pick-ups are nearly empty. The City of Safety Harbor is wishing to optimize their pick-up with the addition of monitored recycling containers. The public recycle cans, especially if they do not have compactors, are emptied at a regularly scheduled pick-up dates and routes. This creates an inefficient situation in which recycle trucks either pick up from near empty cans or full cans are not picked up until the regular schedule. This results in inefficient routing as well as blight or lessened citizen participation in recycling when there is overflow. Kyra Solutions will use Litmus Automation's technology to make the system more efficient and effective. It will either replace or retrofit existing recycle cans with sensors that give alerts by text or email when the cans reach a predetermined load for pick up. The City will then be able to visualize in real-time the capacity of all the recycling bins in the city.

- **Project Status: n/a**

4) Action Cluster: Solid Waste Management IoT Solution

- **Municipal Governments**

  i) South Bend, IN (USA Office of Public Works)
  ii) Pune, Mahashatra India (Pune Municipal Corporation)

- **Members:**

  i) Persistent Systems Inc.

- **Team Lead:**

  i) Brianna Sionne

- **Description:**

  i) Garbage and refuse collection management is a critical function for any municipal government and private township. Inefficient or irregular collection leads to unsafe disposal by the public, which in turn creates conditions hostile to commerce and public health. Accelerite has developed an AWS solution on its Concert IoT platform that offers ready to use "Smart City" solid waste management IOT services. The possibilities for creating public/ private sector revenue generating ecosystems are vast (e.g. selling recyclables and compostable waste to the highest bidder, revenue sharing with citizens to reward participation). Concert IoT's Service Exposure and Monetization modules make it possible to expose services to partners for further innovation such that they can be consumed in a secure access and payments/settlements charging policy enforced manner.

5) Action Cluster: La Marsa Community Connected City: Smart Road Lighting and Traffic Management, Smart Waste Collection

- **Municipal Governments:**

  i) La Marsa Community, GIS department,
  ii) Tunisia

- **Members:**

  i) Bahri Rezig Olfa Dabboussi,
  ii) The National Engineering School of Tunis (ENIT);
  iii) ATCOGEN association
  iv) WAYCON company

- **Team Lead:**

  i) Larbi BEN TILI

- **Description:**

  i) Implement an interactive system to supervise road traffic, parking availability, and control street lighting using integrated sensors and LED technologies. Improve waste collection using smart containers (fill level sensors). Using GIS and wireless technologies (smart phones).

- **Status: n/a**

6) Action Cluster: Recycle Please!

- **Municipal Governments:**

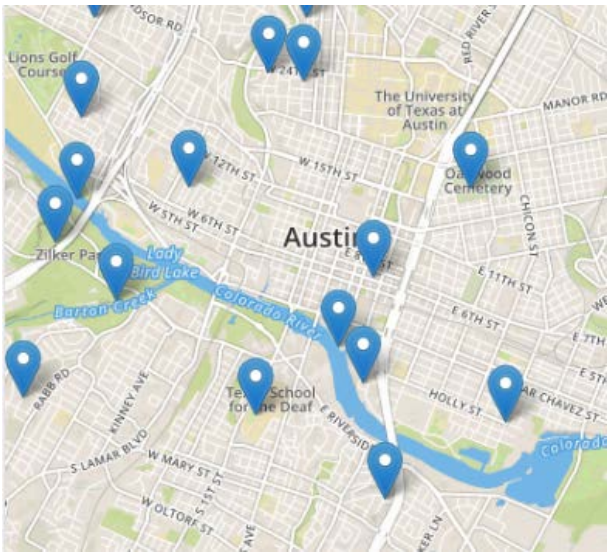
  i) City of Austin, TX

- **Members:**

  i) Open Austin,
  ii) Redeuces,
  iii) Vizias

- **Team Lead:**

  i) Derek Sinns;
  ii) Marco Pineda



- **Description:**

  i) Recycle Please is the coordinated effort of a group of volunteers passionate about improving Austin's recycling process and Zero Waste goals. This project shows users which buildings in Austin, TX do not recycle. The application was developed in partnership with the City of Austin to enforce the Universal Recycling Ordinance (URO) requiring affected property owners to ensure that tenants and employees have access to convenient recycling. The URO is set to go in effect Oct 1st, 2017. The team comprised of volunteers of Open Austin, a Code for America brigade.

- **Project Status:**

  i) Pilot completed – APP in use

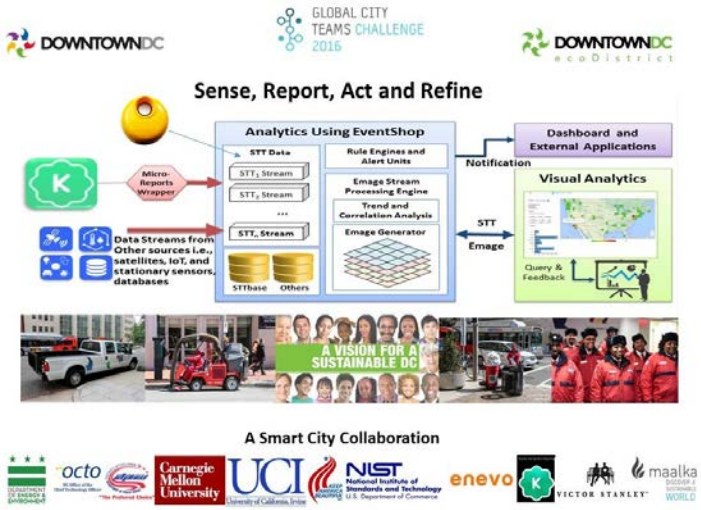
7) **Action Cluster: Sense, Report, Act, and Refine: A Smart City Collaboration**

- **Municipal Governments:**

  i) Washington DC;

- **Members:**

  i) DowntownDC Business Improvement District;
  ii) National Institute of Standards and Technologies;
  iii) Carnegie Melon University;
  iv) University of California Irvine
  v) Victor Stanley;
  vi) Keep America Beautiful
  vii) Krumbs



- **Team Lead:**

  i) Scott Pomeroy

- **Description:**

  i) The goal of the project is to identify ways to use DowntownDC Business Improvement District (BID) personnel and equipment more efficiently as they perform the daily operations of emptying the waste and recycling bins in the BID's service area. The project will utilize a

combination of the latest sensor technologies, condition reporting by individuals, and big data analysis tools to:

- Document baseline conditions, and
- Optimize timing and frequency of daily service routes, and
- Anticipate the impact major events and activities that regularly occur downtown have upon the daily service routes.

- **Project Status:**

  i) Analysis completed - Bins deployed – Action cluster suspended

8) **Action Cluster: Urban Waste and Cleaning Service Level Dashboard**

- **Municipal Governments:**

  i) City of Guadalajara (Spain)

- **Members:**
-

  i) Valoriza-Grupo Sacyr (Spain),
  ii) Telefonica (Spain),
  iii) Technical University of Madrid (Spain),
  iv) InterInnov (France)

- **Team Lead**:

  i) Javier Paniagua

- **Description**:

  i) The goal of the demonstration is to create a visualization dashboard for city utility KPIs that can help city government track SLAs of municipal services. In this pilot, this task will be focused on the generation, visualization and tracking of KPIs for the urban waste management and thoroughfare cleaning services..]

- **Project Status:**

  i) Not Available

Additional Smart Bin Solutions:

9) Product Name: Enevo One

- **Company:**

  i) Enevo – Espoo, Finland

- **Municipalities Served:**

  i) Rotterdam City Netherlands,
  ii) Helsinki Finland,
  iii) Edinburgh, Scotland,
  iv) Washington DC

- **Description:**

  i) Enevo's waste analytics solution provides insights that increase efficiency and transparency. Their sensor is able to measure any type of solid or liquid material. It also measures temperature and sudden movements of the container. The measurements are transmitted wirelessly via the GSM-network to the Enevo One server for analysis and display. Using advanced algorithms the server can forecast when the container will be full (or empty), calculate when the container should be collected (or filled) and which route is the most efficient one to take when driving from one container to another. By optimizing collection logistics based on measurements and forecasts, companies can save significantly in logistics costs and utilize their vehicle fleet more efficiently.

- **Case Study**: Increasing Waste Management Efficiency in Rotterdam City

- **Case Study:** Great Forest Sustainable Waste Management in Washington, DC

10) Product Name: VS Relay

- **Company:**

  i) Victor Stanley – Dunkirk, MD

- **Municipalities Served:**
  i) Boston, MA
  ii) Pittsburg, PA
  iii) Washington, DC

- **Description**

i) More than 20 cities including Washington D.C., Boston, and Pittsburgh are using Victor Stanley Relay for collecting waste and recycling in a more efficient manner from a fiscal, environmental, and community cost point of view. Victor Stanley Relay monitors the fill level of all connected containers and includes a "spike alert" feature that alerts cities if the fill level of a receptacle *spikes* in an unusual manner. This feature has helped Boston catch residents who have dumped residential trash in commercial litter receptacles numerous times. Relay also has the option of monitoring actual weight, in addition to estimated weight based on volume, to assist cities with the optimization of their landfill diversion.

- Establish dynamic collection routing
- Relocate underutilized receptacles
- Identify illegal dumping
- Elimination of overfilling

DASHBOARD

Identify high-priority containers and pressing issues at a glance.

11) Product – Bubble

- Company

  i) Lune – AB Hoogeveen, The Netherlands

- Municipalities

  i) n/a

- Description

  i) LUNE makes waste bins that are used for sorting waste at the source. Their products have been developed and manufactured to fulfill the objectives of the Circular economy. Next to the fact that Lune products fulfill an important role in the end of life and retrieval of other products, our waste sorting bin offer much more than that Lune is closing the material loop by returning used parts as 'new' component in new products. After final use or when damage is done, the usable parts are reused within a new production run. Since all materials are flowing back to the local production in Hoogeveen, brand new business models become feasible. 'Waste sorting' no longer only represents 'costs' (Sell & Forget) it becomes a

service and does no longer only represent ‘costs’ (Sell & Forget). As materials keep most of their added value and products are reused, a logistical flow of materials closes both the material and financial circles. Collaboration with facility management, waste collection companies, suppliers and the Circular Economy network brings a chain of knowledge and innovation to further grow the Circular Economy within the Lune Product portfolio!

HORIZONTAL IOT SECURITY FRAMEWORK AND BEST PRACTICES

The Ever-Growing Importance of IoT

Utilities and other critical infrastructure (CI) industries around the globe are being challenged to improve service delivery while at the same time dealing with security threats that aim to take down their operations. Compounding these challenges are the pressures from investors and regulatory agencies to streamline operations and reduce costs all while dealing with the complexities of a retiring workforce. To conquer these formidable challenges, critical infrastructure industries require greater visibility into their operations and are looking to leverage Internet of Things (IOT) communications technology and communications to provide the means.

In its simplest form, IOT identifies the ability to add communications to existing infrastructure equipment in a customer's operations for monitoring and control purposes via relatively low-cost communication modules. These low cost communication modules can easily enable connectivity to the components in the electrical grid and deliver new levels of near real-time visibility into operations. IOT easily enables connectivity to applications like demand response, distribution automation, load balancing, smart meters and other smart grid applications. With the new levels of visibility, proactive decisions about grid configurations, outages, maintenance schedules, consumption, theft of service and many others are viable. The addition of IOT communication devices facilitates the creation of a highly reliable, highly available Industrial Internet of Things (IIoT) network capable of delivering the needed visibility into your operations during the most critical times. In short, IOT is a game changer.

Despite all of its benefits, utilities and other CI industries have been reluctant to implement IOT communication modules since they have typically only been available on public cellular networks - which haven't been designed for the mission, life, safety and critical needs that critical infrastructure industries require. Utilities have been unable to get private licensed broadband spectrum assigned to their market from the federal government to support their increased data communications requirements. In lieu of obtaining private licensed broadband spectrum, these CI industries are virtually handcuffed to using non-mission critical public networks or even shared unlicensed spectrum to achieve their data needs. This creates vulnerabilities to their critical applications because public communications networks are susceptible to outages and congestion, and shared unlicensed spectrum is subject to interference. Utilities' prefer to own their own private communication networks, which are designed to their specific coverage, capacity, reliability and availability needs. The men and women who support our critical infrastructure require mission critical radio networks that are always available to support their operations and protect their safety. In the face of these challenges, the market has responded and there is good news to be reported. Utilities have traditionally relied on narrowband spectrum for mission critical Land Mobile Radio (LMR) voice systems to provide communications to their field employees. As these systems have transitioned from analog to digital, the ability to support IOT and other IIoT applications becomes viable. Advancements in digital technology can double or quadruple the existing channel capacity on these narrowband Land Mobile Radio systems. Greater channel capacity enables the support of advanced data services — like IOT applications — without impacting voice operations on

these Land Mobile Radio systems. By leveraging the new digital mission critical Land Mobile Radio systems, CI industries can now support both voice and data services like IOT applications on a highly reliable network that provides coverage across their entire service territory too. It's a win-win! Due to advancements in technology and economies of scale, the cost of communication devices has been reduced to price points which enable their use across more infrastructure and applications.

For decades, CI industries have been using a variety of communication technologies in some form or another for supervisory control and data acquisition (SCADA), distribution automation (DA), demand side management (DSM) and other grid-based applications, but they were never placed in a blanket category such as IOT nor were they connected together to create an IIoT. Coupled with the lack of private licensed broadband spectrum options, communication to these applications has been limited and typically only deployed at key locations on a cost-effective basis. Due to advancements in technology and economies of scale, the cost of communication devices has been reduced to price points, which enable their use across more infrastructure and applications.

The energy and utility sectors have been increasingly focused on IOT. It has been estimated that, by 2021, the utility sector will account for 61% of overall IOT device connections, growing at a CAGR of 50%. The same report estimates revenue associated with IOT connectivity will also increase dramatically over the same period, from $5.7 billion in 2011 to $50.9 billion in 2021. Through IOT communication, utility companies can remotely monitor and control assets like electricity substations, capacitor banks, line switches, reclosers and many other key critical infrastructure applications. In addition, utilities can leverage IOT communications for applications like demand response, which provides tremendous cost savings to both the utility and its customers. Enabled by IOT communications, the potential benefits for the energy and utility sectors are far-reaching, including improved energy efficiency, reduced equipment failures, enhanced safety and security, as well as faster and better decision-making.

IOT enables utilities to be proactive in their operations rather than be reactive. Utilities can greatly reduce maintenance and administration costs by automating remote monitoring and cutting down on the number of site visits to check equipment. Scheduling regular site visits to perform routine checks on equipment is time-consuming and expensive, especially for assets in remote locations. With IOT solutions, equipment can be remotely monitored and controlled continuously without human intervention. This allows utilities to check for gradual changes in the status and performance of assets and to schedule equipment maintenance during times that will minimize disruption and inconvenience to customers.

The secure and reliable exchange of information is of paramount importance to utility operations and customer service. As one of the 16 critical infrastructure industries, electric utilities rely on their communication networks to protect lives and ensure the safety of their employees during critical service restoration periods, as well as during normal daily operations, keeping power flowing to the United States. IOT communication is a key differentiator in generating the intelligence that utilities need to make informed real-time decisions.

Key Features of Mission Critical IoT Communications

The most important features of an IOT communication system are:

• **Low Mobility**: IOT devices do not move, move infrequently, or move only within a certain region.

• **Application Independent**: IOT devices enable communications to key applications that don't have any communication today and are completely transparent to the application. The application is unaware that the communication service is provided by a wired or wireless connection.

• **IP-based:** As Land Mobile Radio communication networks migrate from analog to digital, these new digital networks support IP bearer services and have the ability to transport both IP and serial-based protocols over the IP-based network.

• Small Data Transmissions: IOT devices frequently send or receive small amounts of data, leveraging the extra capacity enabled by migrating to a new TDMA-based digital Land Mobile Radio network.

• High Reliability: High reliability means that whenever and wherever IOT communication is required or triggered, the connection and reliable transmission between the IOT device and the IOT server shall be available, regardless of the operating environment. High reliability is required in IOT applications that involve either the prospect of an emergency or highly sensitive data. Utility Land Mobile Radio systems have long been designed for high reliability for their voice needs, and the benefit of this is extended directly to the IOT applications that leverage the same network. Mission critical radio networks are designed for high reliability and redundancy where failure is not an option while business enterprise operations networks are not designed to meet the same redundancy and reliability specifications.

• **Network Priority**: Network priority means that there is a method for providing a hierarchical prioritization of users or applications within the solution when applications, voice or data, are competing for network access. The P25, TETRA and DMR standards and the systems provided by the manufacturers have provisions in their protocols to accommodate a prioritization scheme, whether it is simple or sophisticated. This is important as utilities have long considered their voice communications to be mission critical because they rely on them for both safety and security, such that prioritization cannot be disrupted. Many fixed data applications, which weren't previously considered mission critical, are now being considered as such since the information about the grid's performance has a direct impact on a utility's operation and performance.

• **Security:** Security functions include the protection and confidentiality of IOT data, authentication of users prior to access to IOT devices, and encryption of the data transferred across IOT networks. Knowing that utilities desire private Land Mobile Radio networks for their higher levels of security provides a strong platform that can be leveraged when using the same security for IOT applications.

• **Latency Tolerant:** Latency is a time interval between the stimulation and response. When leveraging a Land Mobile Radio network for IOT the target applications should be those that aren't latency sensitive. The general one-way latency of a Land Mobile Radio network is approximately 1 second. Those polled applications or reports by exception-based applications that don't require immediate responses measured in milliseconds but rather in seconds are target applications for IOT over LMR.

Being the most crucial of the critical infrastructure markets utilities require systems just like their electrical grid that are highly reliable and available to be always on when you need them. Previously, radio systems supporting IOT communications were limited to public cellular and unlicensed wireless technologies – which weren't designed to the demanding levels of reliability and availability that utilities require. The wireless communication networks that utilities have been using for decades that were designed for these high-performance levels have been their Land Mobile Radio systems which provide the mission/life/safety critical link to field crews during both outages and daily operations. The radio system is relied upon heavily for restoration activities and during that time failure is not an option because lives are at stake.

As Land Mobile Radio networks are transitioning from analog to digital they now have the ability to support data communications and IOT devices in addition to the current voice communications – all over a highly reliable and available network that they have relied upon and trusted for years. Enabled with data connectivity, choosing the right digital Land Mobile Radio standard to which to migrate is incredibly important because now both lives and key grid operations are at stake. There are three global IP-based digital Land Mobile Radio standards that are available to utilities and understanding their differences is imperative.

The three global standards are P25, TETRA and DMR and each vary considerably on their applicability for mission critical or business critical use, their maturity level, architecture, security, adoption in the market, and performance characteristics. Despite the fact that the standards have similar sounding feature sets in their marketing materials, their implementation and resulting performance vary greatly so thorough investigation of the technical details is required. Many factors go into selecting to either purchase a new digital Land Mobile Radio technology platform or to leverage an existing digital Land Mobile Radio platform for your IOT communications needs. Digital Land Mobile Radio networks based on global standards like P25, TETRA and DMR offer a large ecosystem of vendors that provide solutions and products to meet a variety of coverage, capacity, security and interoperability needs.

CONTRIBUTIONS

The IoT communications and security content have been provided by Motorola Solutions Inc. with deep communications and critical infrastructure expertise. A special thank you goes to Kreg Christoff and Joel Garner for their support of the Utility SuperCluster group on this topic. Additional information can be obtained here or by reaching Kreg Christoff at kreg.christoff@motorolasolutions.com

Additional IoT information for IoT Cybersecutity can be found at NIST for Framework for Improving Critical Infrastructure Cybersecurity.

UNDERSTANDING UTILITY IOT AND SMART CITIES FINANCING BEST PRACTICES

The Utility SuperCluster recognizes that while technology is now available; it is often difficult to secure appropriate funding to drive full scale technology adoption. Therefore, how technology is financed plays a major role in the success of IoT based solutions. This framework, while supportive of Utility centric investments, can also be applied in smart cities investments in general. This information provides a baseline for understanding challenges, government based options, and two perspectives on how to step out of the box with creative public and private sector funding opportunities. Contributions are provided by Smart Cities Council and Smart Cities Capital and is intended to provide a board understanding of this topic and framework as best practices.

So, let's now start with a better understanding of Smart Cities IoT financing in order to establish a good baseline to determine the best options when looking to finance projects. This perspective is summarized from Smart Cities Council Smart City Finance Guide.

1. City Financial Challenges and Opportunities

In 2008, the world passed a milestone. That year, over half of the world's population lived in urban areas. There's no foreseeable end to the trend that has today's cities expanding at an unprecedented rate and new cities emerging. The world's total urban area is expected to triple between 2000 and 2030 and urban populations could double in that same timeframe. Such rapid urbanization carries significant implications for the world's ecosystems as outlined in a 2012 United Nations report.

Of critical concern is the growth in the number of mega-cities emerging in Asia, South America and Africa. In 2011, the World Bank listed 26 cities with an urban population over 10 million inhabitants and nine of them exceeded 20 million. These mega-cities – places like Tokyo, Mexico City, New York City, Mumbai, Karachi, and Beijing – are enormous. And they're expanding beyond traditional city boundaries into dynamic regional entities. As critical economic hubs, cities contribute to national stability and growth. Yet they are typically resource-constrained – a reality that becomes increasingly burdensome as burgeoning populations put increasing pressure on often inadequate and outdated infrastructure, from water and sewer systems to transportation networks. And these cities will remain fragile and struggle under the demands of a swelling population unless we find ways to move the needle on making them more sustainable. One solution we're seeing in pioneering cities around the world is the use of advanced information and communications technologies (ICT) to make infrastructure smarter and more sustainable. By design, ICT-enabled cities – or smart cities – are more resilient during times of distress due to effective resource allocation and infrastructure management.

Matching the project to the financial tool

Part of the challenge for cities is in selecting the right tool at the right time. As you read through this guide you can familiarize yourself with numerous financing options available for various types of smart city investments and see which ones are most appropriate for specific types of projects.

For instance, the European Commission expects energy consumption to rise by 50% over the next 20 years. That increasing demand for energy and the need to reduce environmental pollution are issues cities everywhere must address. Renewable energy is one obvious solution — but renewable energy projects are extremely capital intensive. The nature of capital projects is that there is a large front-end investment with the benefits captured over the life of the project. Consequently, these are often financed with some kind of long-term financing package. Renewable projects, e.g., solar power also have other challenges; without some kind of subsidy, revenues can't cover operating costs and a return of and on capital. A public-private partnership may be a viable option with this sort of project.

The challenge with many of the newer smart city technologies is that would-be investors see them as high risk because the ROI is uncertain. On the other hand, many projects that have uncertain ROIs can be financed through traditional sources, albeit with lower levels of debt financing. However, projects that embody some element of technology risk– first-of-a-kind projects, for instance – cannot attract debt financing and generally require guarantees or other forms of credit support (or all equity financing). The financing options outlined in this guide generally fall outside the realm of early developmental venture capital. Rather, the tools highlighted in the pages that follow fall into four general approaches:

• Government-based financing tools
• Development exactions
• Public-private partnerships
• Private fund leveraging options You'll see details about each tool, case studies where they are being used and a standard scheme for evaluating them as a potential tool for any given capital project, including common pros and cons with each. But first, let's quickly consider "The Project."

2. Ten Characteristics of Finance Options

Never before have cities had quite so many new technologies to evaluate. Yet the speed and breadth of technology advances – exciting as they are – also pose some real challenges for decision makers: Which investment is the best for the community – and when? And how will the community pay for it? While financing options are not evolving quite as fast as technology, they are evolving nonetheless. But before we drill down on specific options, let's look at the 10 characteristics that should help decision makers see how different types of projects in different types of communities demand different types of financing. This chapter will focus on these characteristics:

1. Sources of capital

A concern when considering finance options is the source of the capital generated by the tool. There are multiple possibilities ranging from dedicated fees for service, targeted tax tools, general tax sources, private investors or even philanthropic support. Understanding the source of the capital is important for three reasons:

• Such awareness will help decision makers understand the institutional context of those responsible for the capital financing decision.

• This institutional understanding will help decision makers be as sensitive as possible to the risk concerns of investors.

• That risk concern will help in constructing the request for financing by highlighting certain aspects of the project that address risk drivers.

2. Number of Parties

Rarely is financing for capital intensive infrastructure projects determined by one person. Normally boards are involved with various members bringing their values and concerns to the decision. Depending on the source of the capital, the parties involved in the financing decision may have conflicting goals or different values. For instance, in a public-private partnership, the values of the public officials will not be driven primarily by a profit motive, as it logically will be for private investors.

Understanding the number and identities of the parties involved in a financing decision will enable a clearer presentation of the project to address everyone's goals. Still, the more parties that are involved, the more challenging the financing is likely to be. The least challenging, of course, are those rare cases where an agency can self-finance its infrastructure investment without reliance on external funding.

3. Ease of securing financing

Not all finance mechanisms provide the same level of accessibility. Some are relatively easy compared to others, and much of the ease is dictated by how sensitive the option is to the risk associated with the project. Another factor that can make securing financing easier is the extent of control the financing agent (whether a utility, local government, limited partnership, etc.) has over the revenue stream dedicated to paying off the investors. The "safer" or more predictable the revenue stream dedicated to repaying the upfront financing is, the easier the financing will be. For instance, in a tax increment financing (TIF) arrangement, the revenues to repay upfront financing are tied to future (and therefore speculative) increased land values or taxes.

Because of this speculative aspect, local governments that seek financing based on TIF arrangements often have to back up the future revenues with promises of other revenues should the future development not materialize. That guarantee lowers the risk and eases the likelihood of financing in such a scenario. As discussed below, lower risk also lowers the cost of borrowing. Ease also involves how stakeholders perceive the option. If stakeholders buy into the project and the financing model, securing the financing can be easier than when they do not. Some of this ease has to do with how the model and its transparency are communicated.

Each tool presented in the guide is scored on this "ease of securing finance" characteristic. The scoring ranges from one (very easy) to five (very difficult). The score takes into account factors such as control

over dedicated revenue streams, how many parties are involved in the decision, risk elements and interest costs.

4. Duration of financing

Different kinds of projects will need different kinds of financing tied to them. Some projects are relatively short term, focusing for instance on material procurement only. In those situations, short-term financing tools will be most appropriate. Other situations may call for medium-term financing.

For example, cities and transit agencies have to finance bus fleets. Such assets have a 12-year or a 500,000 mile recommended life expectancy (though currently the average retirement age for public transit buses has risen to 15.1 years due to budget pressures). Medium-term financing tools would be appropriate for replacing buses on schedule (or other similar capital assets). And this actually saves money in the long run since the maintenance costs for vehicles beyond their recommended life are 10% to 50% higher. Regardless, dedicated transit funding must be available to repay the costs of the upfront capital borrowing.

In situations involving financing an infrastructure asset, such as a major bridge or building, decision makers need access to financing tools with longer time horizons, as these assets have expected life spans that often exceed 50 years. These projects also tend to have significant upfront costs for construction and thus will require access to deeper pools of finance capital. For purposes of classifying each of the finance options, each tool is scored in terms of its most common duration usage:

- Quick tools are those that typically finance projects of a year's duration.
- Short-term tools are for projects of a two- to five-year duration.
- Medium-term tools fund projects with a six- to 15-year duration.
- Long-term tools target capital projects with life spans that exceed 15 years.

Finally, some finance tools are actually ongoing sources that are supported with ongoing dedicated revenues, such as a surcharge on a fee for service collected by a utility. The revenue generated by the surcharge could be dedicated to ongoing infrastructure improvements, a practice common in the telecommunications industry.

5. Risk to investors

Investors want a return that is commensurate with the risk. Buyers of municipal revenue bonds buy based on an assessment (contained in the offering memorandum) of the revenues generated to pay bond principal and interest with the expectation that both will be repaid. Equity investors, for example in a public-private partnership project, take more risk and receive higher returns.

6. Risk to borrowers

Investors aren't the only ones facing risk in a finance decision. Those borrowing the capital (or those they represent) also face risks that decision makers should keep in mind when determining the relative

merit of one funding option versus another. Most of this risk relates to how commitments to pay back borrowed capital are structured relative to the likelihood that the new technology and/or infrastructure will generate the savings or revenues to the extent necessary to cover the borrowing costs.

7. Tax implications

It's important to understand the goals of all of the parties involved in financing smart technologies. For cities interested in creating more sustainable infrastructure, financing is a means to achieve that goal. For an investor, the financing goal is to achieve a reasonable return at an acceptable level of risk.

8. Source of repayment

Financing tools are basically instruments to facilitate borrowing today and repayment over some period in the future — plus interest. As capital is repaid, it and the interest become available for additional financing of other investment options which in turn fuels additional capital growth.

9-10. Advantages and disadvantages

In addition to the eight characteristics above, this guide also highlights some of the advantages and disadvantages of each of the tools. These are all tools that can be used individually or in coordination with other tools to provide capital financing for a wide range of evolving technologies and infrastructure needs. Therefore, one score across all six characteristics is not going to be truly useful as an indicator of the best tool to choose.

Financing tool availability can vary from city to state to country

The financing tools highlighted in this guide are available in the United States today. Most are also available in European Union nations as well, though some go by different names. But not all of the tools are available in every nation.

Furthermore, the tools may be limited to different kinds of projects from nation to nation. This is true even within the U.S., as some of the state-based tools apply only to certain types of investment projects.

So, while this guide illustrates tools, those interested in utilizing them should do their due diligence in learning if and how such tools can be used in their location.

Success is not guaranteed: **Why failures happen**

One final consideration before we get into the finance tool chapters. Any of the tools presented in this guide have the possibility of success. But they can also fail. Here are four examples of why that happens.

First, seeking benefits without doing adequate research can lead to higher costs and lower returns.

Second, market failures can be widespread and intrinsic. Intrinsic features of a system can include information problems, imperfect competition and resource allocation based on existing information and experience and not on opportunities.

Third, funding and model mismatch can occur when funds are not structured or timed appropriately. This can lead to elevated fixed costs, freezes in resources and lower project quality. And accountability to stakeholders is careless. Not to be confused with control, accountability involves reporting on the development of the project and the achievement of pre-determined outcomes and impacts.

Accountability assists with eliminating unrealistic expectations through the course of the project. Not managing expectations with stakeholders can give rise to situations such as the established funding period being too brief — a common problem with financing in the private sector.

Government-based Financing Options for Cities

General funds in most cases are supported by a city's taxation authority as their primary source of revenue to pay for services citizens expect their city to provide. But general funds are usually only available to pay for regular annual operating expenditures.

Many city projects involving smart technologies represent infrastructure upgrades that last well beyond one year. So to protect citizens, cities also maintain capital funds separate from their operating funds. These are used to repay the financing of long-term investments in infrastructure with life spans over many years.

Under the model of public finance, governments issue debt instruments with an agreement to pay back the debt, usually over the lifespan of the item being financed at some agreed-upon interest. By far the most common family of tools to pay for these kinds of capital costs is a government's bond activity.

Bonds are an important method of financing smart cities. Most bonds are issued by governments or corporations with an underwriter that provides the borrower with the full amount of the financing by buying all the bonds issued and then reselling them to investors at a profit on the open market. Of late, bonds have been used heavily to finance renewable energy initiatives. In this chapter, we'll focus on 12 government-based financing tools. Some will be familiar, some perhaps less so:

1. General obligation bonds
2. Revenue bonds
3. Industrial revenue bonds
4. Green bonds
5. Qualified energy conservation bonds 6. Social impact bonds
7. Public benefit bonds 8. Linked deposit programs
9. Energy efficiency loans
10. Property-Assessed Clean Energy Programs
11. User fees

1. General Obligation Bonds

General obligation (GO) bonds are one of two common types of municipal bond instruments. Such bonds are typically used to finance basic core infrastructure investments at the local level of government. These could be GO bonds to finance a new park, a new city hall, a new forensics crime lab, a library, a light rail line, a new school and so forth. In the GO framework, the issuing entity — city, town, county, school district, etc. — backs the issuance of the bonds with the full faith and credit of the jurisdiction. In practice, this means that the jurisdiction will tap its tax revenues at a level sufficient to repay the bond buyers plus interest. Selling bonds yield capital immediately for project construction, with the repayment of the debt taking place over the life of the asset created. The important distinction of GO bonds is that they are guaranteed with taxpayer revenues.

2. Revenue Bonds

A second popular form of municipal bond is the revenue bond. While the GO bond is guaranteed by tax revenues of the issuing jurisdiction, a revenue bond is paid back from revenues generated by the asset the bonds funded. Municipal projects that can generate revenues, such as a parking garage, can be financed with revenue bonds because parking fees can be dedicated to paying back the debt and interest. With a revenue bond, there is no guarantee that tax revenues will "back stop" any shortfall in bond payments should the asset revenues not be sufficient. As with GO bonds, selling revenue bonds yields capital immediately for project construction, and repayment should occur over the expected lifespan of the asset.

3. Industrial Revenue Bonds

Industrial revenue bonds (IRB) are another bond instrument issued by both municipal jurisdictions and state governments. These are most commonly issued as part of an economic development initiative in which the local jurisdiction issues IRBs and gives the proceeds to a private firm for development. These might involve capital improvements, expansions, facility enhancements or renewable energy and renewable energy efficiency upgrades. The firm is ultimately responsible for paying back the debt. That means the debt does not influence the city's rating, since the city has no obligation to repay.

The jurisdiction holds the asset as collateral until the debt is repaid. Because of that, there is often no property tax on that asset. This can be a significant savings for the private firm and is why jurisdictions use IRB deals as incentives to encourage business expansions or relocations to the jurisdiction.

Another appealing aspect is the tax-exempt status of the IRB due to issuance by a government jurisdiction. This means private firms can get lower interest financing through IRBs.

4. Green Bonds

Based on a practice begun in Europe, green bonds are instruments issued to raise capital for funding specific clean power, carbon-reducing projects. Since 2008, the World Bank has issued over $4.5 billion in green bonds. The U.S. federal government seeded a green bond fund with $2 billion in 2004 legislation.

5. Qualified Energy Conservation Bonds

Established by the U.S. Energy Improvement and Extension Act of 2008, Qualified Energy Conservation Bonds (QECB) are another relatively new bond instrument designed specifically to, as the name implies, fund qualified energy conservation projects.

6. Social Impact Bonds

Structured bonds are yet another option for financing capital projects. These bonds determine the value of capital at the bond's maturity. Social Impact Bonds (SIB), also known as Pay for Success, are unlike conventional bonds that offer a fixed rate of return. The SIB payment is contingent on the social outcomes agreed upon by the investor and the issuer.

7. Public Benefit Funds

Public Benefit Funds (PBF) typically support energy efficiency and renewable energy, although not in every case. PBFs were born out of the electric power industry's restructuring in the late 1990s as a way to fund initiatives that were inadequately supported by competitive electricity markets. They also reflect a desire on the part of states to create energy efficiency and renewable energy programs. PBFs are essentially the collection of funds generated by a small surcharge on customers' electricity bills, no matter who the electricity provider is. The surcharge generally ensures that money is available to fund investments by publicly managed efficiency projects. One drawback to PBFs is how they are allocated and reallocated. PBFs serve as tempting targets for state legislators and governors who need to fill state budget gaps.

8. Linked Deposit Program

State treasurers have some discretion regarding options for utilizing surplus state revenues. As the manager of state-generated funds, state treasurers have the authority to invest available state funds in secure loans, often at below-market interest rates, to a guaranteed return.

9. Energy Efficiency Loans

Another tool championed by an increasing number of state treasury departments is energy efficiency loans. These are low-interest loans to individuals who want to finance capital improvements to their homes. While the eligibility for types of improvements varies by state, the general intent is to lower the barriers for homeowners to upgrade their homes with more energy efficient heating and cooling systems, water recycling/reclamation equipment, insulation upgrades, door and/or window replacement and the like. Under these plans, the government or a partnering bank makes the loan,

using state money as the capital for the borrower to use in purchasing and installing the upgrades. Since the capital is state money, the interest rate can be below market rates while still covering inflation losses and yielding a small return on the investment.

10. Property-Assessed Clean Energy

Property-Assessed Clean Energy (PACE) represents one of the newest mechanisms available for financing energy efficiency and renewable energy improvements. This program allows property owners to borrow against their property taxes to fund energy efficiency improvements.

11. User Fees

User fees allow cities and other local jurisdictions to impose fees to cover the cost associated with funding services and enhancements to increase the quality of life and cover administrative and regulatory processes. Not to be confused with taxes, user fees are paid by choice, for example, paying a toll to drive in highway express lanes. Taxes, on the other hand, are compulsory and support government operations across the board. In addition to assigning project costs to project beneficiaries, the attractive thing about user fees is that they can be used to secure financing to fund all or parts of large capital projects.

12. Development Exactions

Government-based financing tools are the most common for funding unproven smart technologies, but they are not the only options available for capital projects. A second set of financing tools highlight the regulatory power of governments to force developers to pay for the infrastructure services their developments will utilize.

These developer exaction tools consist of conditions or financial obligations imposed on developers that help local governments cover the marginal cost increases and load burdens caused by the development. Some of the additional revenue can also be used to provide additional public facilities or services required due to the new growth. With exactions, the intent is to protect the public from the negative effects associated with growth.

Exactions also protect the community from the increased cost of providing infrastructure by passing a portion of the cost on to the developer at the time of development to synchronize the payment of infrastructure. Cities are increasingly relying on exactions to help finance the impacts of new growth on public facilities due to budget shortfalls, cuts in state aid and taxpayers' unwillingness to increase tax rates.

Bringing the Public and Private Sectors Together

Between federal government support waning and lingering effects of the global financial crisis, fiscal strain has become a mainstay for many public agencies. Yet the increasing challenges of urbanization make it imperative that the public sector find creative ways to finance smarter, more sustainable cities.

With this fourth type of financing option we shift from the coercive role of government jurisdictions to a more collaborative approach where public sector and private sector interests work together on a shared project.

This partnering approach has received increasing attention over the last 25 years. Public officials recognize that the private sector traditionally has access to larger pools of capital — human, knowledge and financial. And working with the public sector has distinct advantages for the private sector in terms of zoning and access to public spaces.

Today the challenge in many areas is determining which services or parts of service delivery are best managed by the public sector and which might be better managed by private or nonprofit partners. New arrangements involving partnerships with the private sector, nonprofits and international non-governmental organizations are emerging with increasing regularity.

We'll look at four public-private financing vehicles in this section:

1. Public-private partnerships
2. Pay for performance

1. Public-private Partnerships

Public-private partnerships – sometimes referred to as PPP or P3 — are agreements between a public agency (federal, state or local) and a private-sector entity that uses the specific skills and assets of each sector for the delivery of a service for the general public. P3s are probably the most complicated and least understood financing tool available to cities, but one that more and more cities are embracing. These partnerships can take many forms, but they generally seek to balance responsibilities, risks and rewards among all parties involved. They align the public good with commercial objectives designed to enhance the private sector's bottom line. Cities interested in investing in smart technologies, for instance the contact-less transit ticketing system mentioned earlier, face substantial upfront costs. For most jurisdictions this poses a challenge due to constrained budgets. Yet partnerships with private sector companies are particularly useful because they can offer technical support, capital funding and oversight of operations.

2. Pay-for-performance

Pay-for-performance contracts (or performance contracts) are similar to the social impact bonds. They are commonly used today for energy-related projects. Performance contracts usually involve a private-public partnership where the private sector works with the public sector to implement a new more efficient or more sustainable technology. In most cases, the private sector business will offer financing for equipment, repairs and new developments. In exchange, both entities enter into a performance contract where the private partner identifies and recommends efficiencies that can be paid for through the savings realized.

Typically, upgrades are guaranteed to the point that savings will meet or exceed annual payments and cover all project costs. Should the anticipated savings not materialize, then the private partner pays the difference. Pay-for-performance contracts can be very beneficial for both public and private partners. The contracts provide financing as well as project development and implementation costs. The owner gets the immediate advantage of savings from reduced consumption without making a capital investment or assuming debt. But there are drawbacks to performance contracts. Projects financed with performance contracts are more expensive and less capital efficient. The owner will pay higher (non-tax exempt) interest rates – two to three times higher than tax-exempt rates by relying on performance contract financing.

6: Tapping the Private Sector

Government-led financing, development exactions and public-private partnerships are all groups of financing tools in which public sector money plays a significant role. The challenge in recent years has been attracting more private investment dollars into the finance market for smart infrastructure projects. Leveraging private sector funds, which are potentially larger pools of finance capital, can be useful for financing projects that will improve livability and have long-term impacts on a city's economy. State governments often invest in private sector funds as a way to diversify their investment portfolios.

For the private investors, investing in new technologies can improve their company's bottom line by attracting consumers and reducing costs. It's important to note that there can be some unintended consequences in leveraging private sector funds, such as excessive or unbalanced risk exposure or insufficient returns.

Private sector finance tools are categorized in the following list.

1. Loan Loss Reserve Fund (LRF)
2. Debt service reserves
3. Loan guarantees
4. On-bill financing
5. Pooled bond financing
6. Pooled lease-purchasing finance
7. Value capture
8. Tax increment financing

1. Loan Loss Revenue (LRE)

Under the Dodd-Frank Wall Street Reform and Consumer Protection Act, President Obama signed the Loan Loss Reserve Fund (LRF) in 2009. Although LRFs are not a new banking concept, LRFs help improve under-banked consumers' small-dollar loan options by expanding the number of responsible lenders and products available in the marketplace. LRFs are useful in markets where financial institutions make a series of small loans for projects such as energy efficiency improvements.

2. Debt Service Reserves

Debt service reserves allow states and local jurisdictions to set aside cash reserves to guarantee the payment of the principal and interest of a bond. Much like a loan loss reserve fund for private loans, this service is useful for bond issuers who want to boost the security of their bonds and states or local jurisdictions that want to expand the market for their bonds while reducing the bond coupon rate.

3. Loan Guarantees

One method that U.S. states and many nations use to minimize risk for private investments is guaranteeing the repayment of a loan in case of default. Similar in logic to the loan loss reserve funds, loan guarantees allow the federal government to work with private companies and lenders to mitigate the financing risks associated with new projects.

4. On-bill Financing

When smart cities encourage their citizens to adopt new green technologies, public-private partnerships can often be leveraged for the best possible outcome. Yet citizens are often slow to adopt new technologies due to lack of upfront funds to pay for them, reluctance to adopt something unfamiliar, unforeseeable savings and high financing costs. In such cases, two types of programs are available to citizens to accelerate adoption: utility-enabled financing and repayment and user fees. On-bill financing (also known as utility-enabled financing and repayment) allows the local utility to decide the best upgrade package that can be reasonably financed. The utility then oversees the upgrades and customers are assessed a fixed monthly charge on their utility bills to pay for the upgrade.

5. Pooled Bond Financing

Pooled bond financing is another option that helps generate new capital. Predominantly for state and local governments, nonprofits and private companies can benefit from pooled bond financing too. With this tool, a sponsor sells an issue of bonds, the proceeds from which are used by a number of state or local jurisdictions, or other tax-exempt organizations. The goal is usually to help smaller borrowers (e.g., small towns) get access to capital with lower costs than they might be able to on their own, given their credit ratings. The bond program features a common debt service reserve fund, which is funded from proceeds from each bond sale and kept at a level equal to 5% of the principal amounts on each individual loan. The common debt service reserve fund is meant to enhance the credit strength of the program so that it is greater than the credit of individual borrowers. Using bond insurance, premiums are allocated to each borrower based on their credit strength, so no borrower is subsidizing any other borrower.

6. Pooled Lease-purchasing

With pooled-lease purchase financing, a government agency purchases property or equipment on an annually renewable contract. Financing can come from either a financing institution or the government may issue certificates of participation where investors can purchase a share of the lease revenues. At

the end of the lease, the agency that issued the debt can sell the property or equipment to the jurisdiction for a minimal amount. This financing mechanism is particularly beneficial to states because smaller projects can be combined to receive longer loan terms and lower interest rates. However, forming a pooling agreement can be difficult when attempting to combine projects at the same time for financing.

7. Value Capture

Guided by the principle that those who benefit from public infrastructure should pay for it, value capture is the identification and capture of increased land value from resulting public investment in infrastructure. Local governments have widely used value capture instruments to incentivize and/or invest in infrastructure improvement in blighted areas where private investment risk would be high. Using special taxes and community improvement fees, local jurisdictions can capture part of the value created for private investors as a result of the jurisdiction's investment in improvements. For instance, an improvement in a city's public transit system that upgrades the system's efficiency and accessibility is a benefit to neighboring properties. This benefit is the increase in higher land values and, perhaps, an increase in business for property owners. Since they benefit from the improvements made to the transit system, they should pay for receiving those benefits through the city's choice of assessment, which could be an imposition of public transit impact fees, land-value taxation or capture of property tax increments through TIFs.

8. Tax Increment Financing

Tax increment financing (TIF) is a public financing method that essentially finances debt in anticipation of future tax revenues. TIFs allow cities to begin infrastructure and community improvement projects with borrowed funds with a promise to pay those funds back with additional tax revenues generated from the increased property value in the area around the development. In many areas where TIFs are used, the area of proposed improvement is categorized as underdeveloped, blighted and as a site with potential to save and/or bring in money if developed. TIFs usually pay for streets, sewers, parking facilities, land acquisition, planning expenses, job training, demolition and clean-up costs. In most cases, cities consider TIF projects a viable option because the proposed development of the area is anticipated to spark an increase in property values. The logic of this form of financing can be applied to smart infrastructure projects as well.

Conclusions and additional resources

Governments around the world are coming to terms with the realities associated with the population explosion on the way and the urbanization it will spawn. Innovations in technology will dramatically improve the livability, workability and sustainability of tomorrow's cities. New ideas for matching solutions to problems through partnerships between the public, nonprofit and private sectors are emerging every day.

The challenges presented by increased urbanization are not insurmountable, but do require entrepreneurial approaches that bring to bear the creativity of the private sector with the commitment of public officials. As we've emphasized, the single greatest barrier to meeting these challenges is financing. The information provided focused on financing tools available to decision makers looking for the right financing option for their project. Not every tool is available in every jurisdiction around the world, but the collection serves as a starting point for exploring options. And city leaders will need to consider some of the nontraditional financing arrangements that may prove a better fit for the kinds of smart technologies they want to see in their communities.

Contributions

This material is shared with the written approval from Smart Cities Council from their Smart Cities Finance Guide. The full report is available here. A special thank you is provided to Jesse Berst, Founder and Chairman of Smart Cities Council for supporting the NIST GCTC Utility SuperCluster.

A Second Financing Perspective

This second smart cities perspectives is provided from Smart Cities Capital and focuses on public-private financing as an innovative approach to financing smart cities IoT based projects.

Smart city and IOT adoption have two common challenges The first being actual "know-how" and an even more significant challenge, is a flexible consumption and/or self-funding and variable risk, structures. Establishing an end-to-end, collaborative, ecosystem that can provides experience and "know-how", while leveraging disruptive vendor agnostic outcome based business model, on a multi-year, portfolio based structure, assures that the overall requirements can be addressed and not just a fraction of what is required.

The learning curve is great and the typical approach of various proof of concepts have proven to not be the most effective as many equipment of solution manufactures have the ability to self-fund a few hundred thousand dollar pilot, yet few, if any have the risk and financial appetite to exit the pilot and fully fund the long term, multi-million dollar smart city project in a fashion that allows the municipality to implement said project in a fashion that is either self-sustaining or better yet, can actually generate revenue that covers the monetizing projects AND can support other projects, that cannot be monetized such as safety and security, etc.

Herein lies the conflict where lots of traditional money exists in the market, and lots of technology and service providers want to support smart city projects, however, most want to do it under legacy models where the investment grade counter party (City, state of with the support of a risk mitigating agency), is assuming the risk and therefore the manufacturer or service provider can recognize the sale, the government agency assumes all of the risk in what may appear to be low cost funds, yet WITHOUT considering risk adjusted outcomes since the monetization, for the most part relies on variable risk factors such as off-load, our of home or savings share in order to achieve the required CAPEX and on-going OPEX for a 10 to 25 year project.

SMART CITY COMPLEXITIES / REQUIREMENTS (BULLET FORM)

- **Smart City Complexities:**
  - Many cities understand the importance of transforming via Smart City Projects, few know how to actually do it.
  - Most Cities and Agencies agree that budget and flexible risk sharing models are required even when funding is relatively inexpensive as is the case with municipal bonds, pension funds and traditional loans and leases. Even if they cost at a 0% cost of funds, most have no ability to commit to additional debt and existing or available funding is far lower than projects require.
  - Leaders and general citizen, due to lack of information or understanding, object city assets / revenues being in the hand of 3rd party entities.
  - PPP's development can be a protracted process requiring significant work extending cycles beyond SC critical path timelines
  - Legacy / existing bond or Federal funding programs may severely limit how existing assets can be included in SC project.
  - Majority of the larger and comprehensive SC projects will be true first of its kind or with limited existing POC's globally

Current Reality:

The aforementioned conflict has resulted in a reality where many solution and service providers, along with tier-1 cities, have implemented pilots:

- Which cannot be exited
- Where project cycle times are taking much longer than expected
- Have quickly introduced uncertainty as it relates to on-going investment versus true revenue
- Deliver margins for the providers, yields for the investor and outcomes for the respective government agencies in a manner that cannot live up to the expectations of all concerned parties

Today, the consultants, advisors and tradeshow promoters tend to be the primary ones actually making money. Meanwhile, many of the same core players and cities meet in multiple venues, discussing the same key points.

Other additional points are also material in that a majority of the attention is being focused on the tier one cities, and an equally important need exists in tier 2 and 3 cities, as well as rural areas.

Factors that are also indirectly impacting the market are accounting changes where muni leases may no longer be treated outside of the cities balance sheet as well as the under appreciation of the escalating operational cost of processing the exponential data that smart city projects generate, while only a 15% to 30 % is actually valuable. Investment in city owned data center required expansion or even 3rd party cloud providers is a material cost regardless of the option selected.

As this document will illustrate, real solutions exist which can overcome these challenges, if they are leveraged.

Overcoming Challenges, Leveraging New and Emerging Solutions and Providers:

In order to overcome most of the key challenges, it is important that a city work with a consortium that can truly deliver an end to end solution that covers both the "know-how" and variable risk funding challenges.

The following represents these key solution attributes, which include but are not limited to:

Needed Eco-System Coverage and Capabilities:

- Must have Strong Project Focused, Financial Backing, For Projects of All Sizes
- Ability to Build, Operate and Transfer Projects, with Terms Lasting from 10 to 25+ Years.
- Varying Business Models Supporting, Project Financing, Savings Share, Revenue Share, with matched funding for each type of risk.
- Portfolio Approach, Allowing A City to Combine Various Project Types Over a 3 to 5 Year Horizon.

Required Project Portfolio Models (Partial List):

- Smart City and Internet of Things (IOT) Solutions:
  - Self-Funding – Monetized Solutions
  - Savings Share Structures (Lighting, Transport / Fleet, Connected Assets, etc.)
  - Structured Finance / Debt (In Lieu of Bond or Similar Structures)
  - XaaS / Private Cloud / Dynamic Data Center as A Service (Supporting Data Processing)
  - Structured Debt and Muni-Leases (Covering the City's Committed Portion)
  - Legacy Asset Conversion (CAPEX to OPEX, enabling off-balance sheet treatment)

Existing Funding AND Net New Revenue Sources, Details:

- **Existing Committed Budget / Funding (CAPEX OPEX)**
  - Approved annual procurement and capital improvement budget
  - Approved and on-going annual Operating Expenditure Budget
  - Previously issued Bond or similar public debt funding
  - Federal, State or other Agency provided funding
- **Net New Revenue Sources (Monetizing of Smart Parking, Smart Lighting, Smart Transport, etc.)**
  - WIFI/ Access capacity (core and excess) sold to local Service Providers and Virtual Service Providers (off-load fees)
  - Advertising Revenue embedded into Smart Lighting, Smart Transport, etc. (Key revenue in various projects)
  - Smart Project (Smart Parking, etc.) generated revenue from parking operation, tolls, concessions fees, applications, etc.)
  - Big Data Analytics subscription by targeted interested parties

- Application Revenue Sharing, supporting learning, commerce / shopping and similar uses
- Structuring / Origination Fee charged to some of the eco-system partners linked to specific Smart Project enablement

IMPLEMENTATION COSTS (TYPICAL)

- **Project Specific Expenses:**
  - Procurement of Required Bill of Material (BOM) Solution (Hardware, Software, Services, Applications, etc.)
  - Installation, integration and on-going maintenance / management of the SC specific project
  - Required Licenses / Fees required for the providing of actual services
  - Project Specific Taxes, registration and other fiscal and legally required expenses.
  - Replacement, Tech Refresh assets, if applicable, parts required to adhere to project specific service level agreements
  - Reserve to cover penalties associated for breach of related SLA item
    Reserve for early termination and fiscal out option required in committed SC funded projects.

- **Smart City Adoption / Project Success Requirements**
  - Top down support is critical from the city or agency and long standing silos make cross-agency support difficult.
  - Ability to directly engage with; A) Agency or City Head, B) CTO / CIO, C) CFO or Finance Leader, Collectively D) P3's leader if applicable, Legal and Support Personnel.
  - Long Term Concession (10 years to 25 plus years) supporting net new revenue sources (Advertising, Big Data, Off-load Fees).
  - Creation of collaborative partner Eco-system enabling a true end to end solution covering both enhanced Citizen Experience and Net New Revenue sources supporting a portfolio approach leveraging committed and new revenue sources.
  - Engagement model that allows for linking of various SC projects in order to deliver a comprehensive project.
  - Experienced project team (Project Managers, Contract negotiators, PPP and Agency liaisons, etc.)
  -

Smart City Adoption Challenge Framework Net Away:

Smart City solution adoption is critical for a city's economic development and the challenges for the city and the solution providers are real, however the outcome based model approach referenced in this document can help cities of all sizes. Applying these solutions across the top use cases can solve the challenges faced by the solution and service providers as well.

An important point of clarification, is the need to work with a business model or solution provider that is truly agnostic as to the actual hardware so that the city or agency can select from all available options and not be held limited to solution providers that finance only that OEM's and other non-competitive products.

Summary value points covered in this framework are:

- Provides the Smart City expertise / know-how required in order to accelerate typical learning curve.
- Supports Projects to be realized with reduced or no risk / cost to the City or Agency (incremental CAPEX and OPEX budget)
- Directly provides incremental revenue creation via revenue-sharing or savings share.
- Allows SC projects to move forward that would otherwise not be able to or could only be a fraction of required solution.
- City is able to retain control of its destiny, including data and other valuable assets via an enhanced structure versus other models that may appear to be free, yet reduce value and control for the agency or City.

The recommendation is to work with innovative, end to end solution providers (technology, business and operate model), and not just legacy players, so that the city's smart city objectives can be positively impacted, driving economic development and digital inclusion for all.

Contributor

Oscar Bode is the CEO & Founder of Smart City Capital. Smart City Capital (SCC) is a new global company formed by leading IT industry executives, highly experienced in IOT, Smart Cities, Service Provider (Backhaul, Small Cell, Cloud and XaaS), and Outcome Based funding solutions. Smart City Capital has an end to end partner eco-system including various fortune 100 technology, service providers and operators, channel partners, lenders and asset managers.

Additional information can be found here or by contacting Oscar Bode at obode@smartcitycapital.net

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- Water - Ken Thompson, Technology Fellow at CH2M HILL
- Energy - Derick Lee - Founder & Chief Architect at PilotCity and Deborah Acosta, Chief Innovation Officer at City of San Leandro
- Waster - Scott Pomeroy, President at Scalable Strategies

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- IBM – Mike Alexander, Distinguished Engineer
- Siemens - Ken Cornelius, President, Center of Competence

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- Rasheed Ahmad, Watershed Manager
- Jairo Garcia, Director Climate Policies and Renewables

In closing, sustainability of resources like those found the utilities vertical (Energy, Water and Waste) will continue to be at the forefront in the adoption of IoT technology as a result of population growth and environment pressure. The undertaking completed by this working group is a great starting reference point for cities to develop and implement their own customized Smart Cities IoT plan.

Sincerely,

Ed Davalos – NIST GCTC Utility SuperCluster Chair
Motorola Solutions – WAVE Unified Communications Sales Leader

About Ed Davalos
Ed Davalos is the WAVE Carrier and Commercial Markets Enterprise Sales Leader at Motorola Solutions Inc. for WAVE OnCloud, WAVE 5000 and 7000 On Premises products and services He is responsible for the development and implementation of carrier channel strategy for vertical and commercial markets.

Previous experiences spans more than 25 years in the communications and IoT working in the federal, state and local, utilities, energy, education and healthcare verticals. He has held a variety of leadership positions in sales, marketing and product management with AT&T, Nextel/Sprint and Schlumberger before joining Motorola Solutions.

Currently he is the work group chair for the National Institute of Standards and Technology (NIST) Global Cities Team Challenge (GCTC) Utility Super Working Group focused on acceleration and adoption of IoT technologies. The working group consists of 100 members segmented into three sub groups (Energy, Water and Waste) with 20 deployed demonstration projects globally.

Prior to leading the Utility SuperCluster group, he lead a utility infrastructure focused action cluster and implemented three IoT water projects (City of Atlanta, Las Vegas & Los Angeles) focused on resource sustainability by reducing leaks in water transmission and distribution systems.

Moving forward, Motorola will continue to lead the Utility SuperCluster group with Kreg Christoff and Ed will transition to the NIST Public Safety Communications group focused on providing unified broadband communications to address the need for interoperable communications for emergency and business operations centers.

Previously he served as co-chair of the Homeland Security Working Group at the Georgia Electronic Commerce Association resulting in the first public safety training exercise for emergency and business operations centers to increase collaboration and interoperability.

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